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RABIES IN WILDLIFE AND CONTROL METHODS IN NEW YORK STATE [1]

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ABSTRACT

Since the first laboratory-confirmed case of rabies in wildlife in New York State was reported in 1941 the disease has become a serious problem. Principal vectors are the red fox and gray fox. The seasonal incidence of rabies in foxes can be closely correlated with fox movement. Records indicate that the prevelance of rabies in in foxes and cattle, as well as its over-all incidence in all species, has shown periodic fluctuations during the last 14 years. The geographic distribution of rabies in New York may be grouped into three classifications: endemic, sporatic and isolated.

Control efforts by means of intensive fox trapping have been carried on by the State since 1946. Three methods have been used: (1) trapping along a line about 5 to 10 miles wide around the infected portion of the State; (2) trapping in several zones about 50 miles wide outside the infected area; (3) trapping in a zone within and on the periphery of the infected area. Various census methods have been used to assess relative fox population densities. Other control programs by county personnel, financed in part by State aid, have also been undertaken.

The control operations carried on have not eliminated rabies in New York or wholly prevented its spread. Nevertheless, reduction of fox abundance appears to have reduced the incidence of the disease in the infected portion of the State, and intensive trapping has virtually eliminated it in certain areas for several years at a time. The consensus of those administering the program is that the present approach is the best one available.

Much information has been published relating to rabies in wildlife and control methods in New York State. Several technical papers have presented certain aspects of the problem, and the monthly and annual reports of the wildlife rabies control program have evaluated progress and problems. Numerous articles have appeared in magazines and newspapers.

As control measures have probably been more intensive here than in other states with similar problems, a summary of the abundance, distribution and fluctuations of rabies in wildlife, together with an evaluation of census and control methods, should be of value.

RABIES IN WILDLIFE

Records indicate that rabies has persisted in New York State since colonial days (Korns and Zeissig, 1948). It was not recognized in wildlife, however, until recently. Reports dating back to 1925 indicate that prior to 1946 rabies was most prevalent by far among dogs and that livestock losses attributable to it were almost non-existant until 1943.

[1] Acknowledgment is due E. L. Cheatum, Harvey Warner, James Kelly, Lloyd Signs and Franz C. Winter of the New York State Conservation Department for critically reviewing the manuscript. The author is indebted to Richard L. Parker, Chief, Mid-West Rabies Investigations Station, Poynette, Wisconsin, for valuable advice and criticism and for permission to incorporate much of his work into this paper.

History

In 1941 the first case of rabies in wildlife (in a fox) was diagnosed in the laboratory. In 1943 another rabid fox was reported. In 1944 a mild outbreak of the disease occurred in Chautauqua County in the southwestern portion of the State. At this time 15 cases were confirmed in foxes, but for some unknown reason the outbreak declined. In the summer of 1945 a rabies epizootic occurred in central Broome County in the south-central portion of the State (Figure 1). From this center of

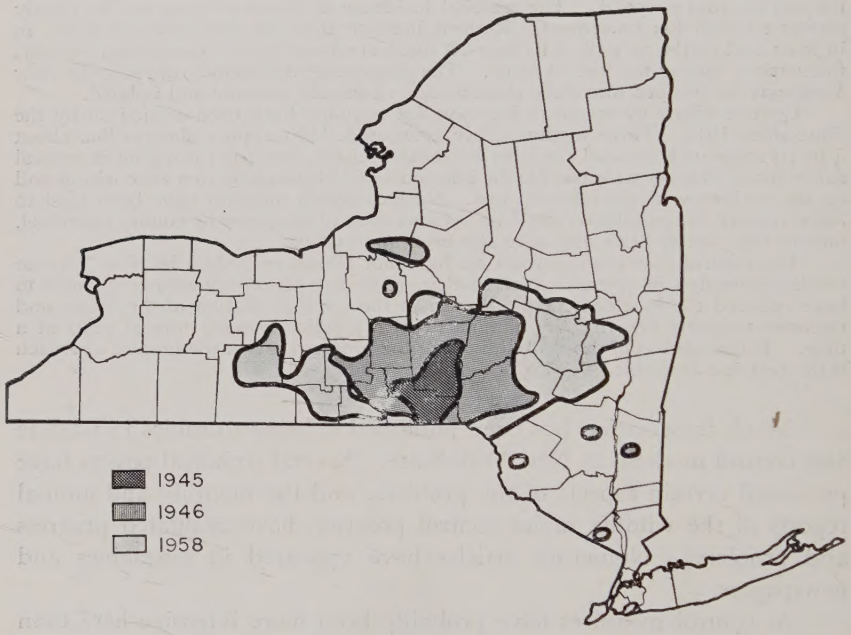

Figure 1. Spread of rabies, 1945–1958. (Modified from Colson *et al.*, 1955).

infection rabies spread eastward, westward and northward. During 1945 a total of 663 cases involving a variety of species were diagnosed. Fifty cases were reported in foxes and 503 in dogs.[2] The highest annual rates of incidence, for all species, were reported in 1946 and 1950. During these two years 309 and 497 cases, respectively, were reported in foxes (Table 1).

Records indicate that after the initial outbreak in Broome County the incidence of reported cases, as well as the distribution of the disease, increased very rapidly. The recent rabies epizootic among wildlife in

[2] Rabies among dogs, for the most part, ceased to be a serious problem with widespread use of immunizing vaccine begun in 1946 and 1947.

TABLE 1. REPORTED ANNUAL INCIDENCE OF RABIES IN NEW YORK STATE (EXCLUSIVE OF NEW YORK CITY) 1940–1958

Year	Species							Counties infected
	Man	Dog	Cattle	Fox	Cat	Other	Total	
1940.....	0	100	2	0	0	0	102	7
1941.....	0	107	0	1	1	0	109	8
1942.....	0	62	0	0	0	2	64	6
1943.....	0	176	10	1	1	1	189	13
1944.....	1	233	47	15	12	6	314	18
1945.....	1	503	87	50	15	7	663	3
1946.....	0	377	440	309	19	30	1,175	8
1947.....	0	52	329	275	18	22	696	18
1948.....	0	23	225	258	24	38	568	23
1949.....	0	16	172	278	20	29	515	26
1950.....	0	37	367	497	62	59	1,022	29
1951.....	1	48	214	183	51	42	539	23
1952.....	0	16	174	101	26	20	337	26
1953.....	1	45	210	129	42	11	438	28
1954.....	0	26	250	155	23	18	472	22
1955.....	0	42	240	168	37	32	519	22
1956.....	0	37	133	99	22	15	306	26
1957.....	0	13	110	49	26	4	202	21
1958.....	0	21	146	56	21	17	261	26

the Province of Ontario (Canada) followed a similar pattern (Fyvie, 1958). The disease spread rapidly and, within a few years, the incidence rate had greatly increased. It appears, in certain instances at least, that upon introduction in a rabies-free fox population there is an initial explosive epizootic in which the disease spreads rapidly, but that thereafter it becomes considerably less prevalent in that area. This may possibly be associated with high fox populations which, after having been initially reduced by the disease, are kept at lower density levels by periodic and localized outbreaks.

VECTORS

Parker (1958) stated that 93.4 per cent of all wildlife cases in New York State were reported in foxes and that raccoons and skunks accounted for an additional 6.2 per cent. Rabies has also been diagnosed in bats (*Eptesicus f. fuscus*), opossums, white-tailed deer, rabbits, a coy-dog, a coyote, an otter and a beaver. The red fox (*Vulpes fulva*) is more common in New York than is the gray fox (*Urocyon cinereoargenteus*). Catches by trappers under the wildlife rabies control program for the years 1951 through 1957 indicated a ratio of one adult gray fox to nine adult red foxes. Since trappers normally "trap for the red", this ratio may have been somewhat high. Also, ratios probably differ between localities.

During the mid-forties fox populations in the northeastern states increased. It is quite probable that this increase, in addition to a reduced

harvest because of the low market value of pelts, was responsible for the rabies epizootic which occurred among wildlife.

FLUCTUATION AND DISTRIBUTION

Suspected rabid animals are submitted to diagnostic laboratories located at the State Department of Health in Albany, the New York State Veterinary College in Ithaca, and the Hamilton Hospital for Animals in Ripley. Smears and sections of brain tissue are made, and the presence or absence of Negri bodies is noted. Questionable cases are confirmed by mouse innoculation tests.

A graphic presentation of reported cases of rabies among foxes, by month, shows a seasonal variation, the greatest number having occurred in March and April, with a lesser peak in October (Figure 2).

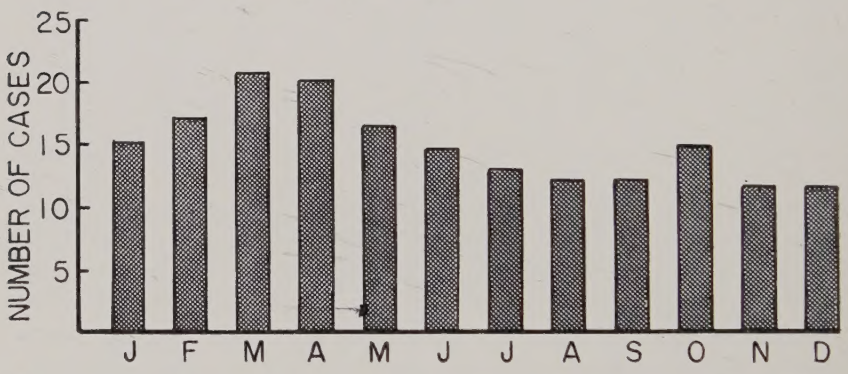

Figure 2. Seasonal incidence of reported cases of rabies among foxes, 1944–1957. (After Parker, 1958).

Allowing for an incubation period of approximately 45 days, maximum infection occurs during that time of year (late January and early February) when foxes are "pairing off" and mating, a period of great movement. The secondary high in the rate of infection occurs about the time family groups begin to disperse and fox pups seek new range.

Available records suggest that the occurrence of rabies may be somewhat periodic (Figure 3). This graph also shows a close correlation between the trend among cattle and that among foxes. It is believed that the most nearly reliable indicator of the general prevalence of rabies on a statewide basis is the reported bovine cases. As the State pays an indemnity for cattle losses due to rabies, it is felt that reported losses closely approximate actual losses. On the other hand, the percentage of rabid foxes submitted for diagnosis is extremely small. Obviously many infected foxes never come in contact with humans. Estimates of the percentage of rabid foxes actually submitted and diagnosed

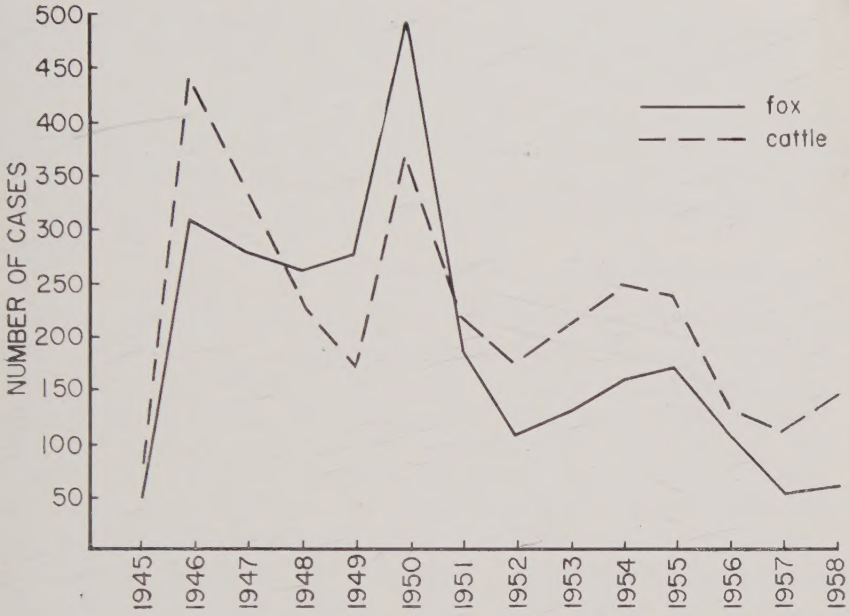

Figure 3. Annual incidence of reported cases of rabies in foxes and cattle, 1945–1958.

in the State have ranged from 1 to 10 per cent. This percentage will, of course, vary according to the proximity of diagnostic facilities and the general public's awareness of the disease.

Parker (1958) and others noted that in certain sections of the eastern portion of the State rabies appears to be endemic. It has been consistently reported from certain counties in this area for a number of years. Parker examined over 1,300 rodents and insectivores from the endemic area in an attempt to isolate the rabies virus. The theory was advanced that rabies might be endemic in small mammals and that this might account for its persistence. However, with the exception of a single bat, the results were negative.

Other areas to the north and west, on the periphery of the endemic region, have experienced sporadic outbreaks of rabies for several years and then have remained rabies-free for a time. Also, in numerous instances, apparently isolated cases occurred considerable distances from any known center of infection. This may have been due to a lack of confirmed reports as the disease spread. Possibly some other explanation exists.

It has long been established that rabies in wildlife is a density-dependent disease. That is, it tends to spread in the direction of and through adjacent, higher vector populations and, subject to seasonal variation, the higher such a population the more rapid the spread. In New York the chief vector is the fox. It has also been observed that

rabies has a tendency to spread along ridges and through valleys, perhaps because foxes tend to prefer such routes when traveling.

CONTROL OF RABIES IN WILDLIFE

The distribution and incidence rate of rabies in wildlife is such that control measures are necessarily a State function. However, counties may also undertake control programs.

INTERDEPARTMENTAL RABIES COMMITTEE

The Interdepartmental Rabies Committee, consisting of representatives from the Departments of Agriculture and Markets, Conservation, and Health, was formed in 1948. The Department of Education was later asked to participate. It was felt that the problems were such that representation from these four departments was necessary to obtain a comprehensive picture of all aspects of the disease. Among other functions, the Committee coordinates rabies control activities and information relating to the disease within the State as well as with government officials in other states. The Committee also determines the areas or zones to be trapped under the State wildlife rabies control program. Trapping zones are determined by the number and distribution of reported rabies cases, the areas trapped in previous years, the fox population densities in critical areas, and the trapper personnel available.

STATE WILDLIFE RABIES CONTROL PROGRAM

The function of this program is to control the incidence and spread of rabies in wildlife by intensive fox trapping in critical areas. Trappers were first employed by the State for this purpose in 1946.

ORGANIZATION In 1946 and 1947, State trappers engaged in rabies control were supervised by one of the Conservation Department's district game managers. In 1948 a coordinator was employed to direct field operations, carry out recommendations of the Interdepartmental Rabies Committee and handle public relations. Present personnel consists of a coordinator, two trapper supervisors, six full-time trappers and about 14 seasonal trappers. Seasonal trappers are employed during the "active phase" of the program which starts in April and ends in November. Most of them generally return year after year and replacement is negligible. Winter trapping is not economical because of unfavorable weather conditions, However, the six full-time men are retained to provide a nucleus of experienced trappers and are assigned to trap or census in critical areas during the winter months.

Trappers are generally assigned to one town for a month, the town being a convenient unit both for delineating the area in which the trapper is to work and for preparing progress reports. Trappers work consecutive

days until about the 22nd of the month, when they pull their traps and take accumulated time off. In most cases three weeks of trapping per town is sufficient to reduce the fox population to the level desired. However, should the population in a certain town be high, additional trapping may be desirable. Since trapping during the spring and early summer is difficult due to weather conditions and limited fox movement, towns trapped at this time may require additional trapping during the fall months.

CONTROL METHODS Initial control measures by the State began in early 1946 when several trappers were assigned to trap foxes within areas having a heavy incidence of rabies in foxes. In the fall of 1946 additional trappers were employed and a system of "line" trapping was begun. This consisted of trapping along a system of interconnecting roads located on the periphery of and encircling an infected area. The width of this "line" was limited to approximately half a mile on either side of the road. In 1947 the line was widened to about 5 to 10 miles (Figure 4). However, control by this method was not effective.

During an intensive study of fox-pheasant relationships begun in 1947 (Robeson, 1950) it was found that a 75 to 80 per cent reduction of the fox population over a wide area prevented the spread of rabies into this zone. Consequently a system of "zone" trapping was undertaken

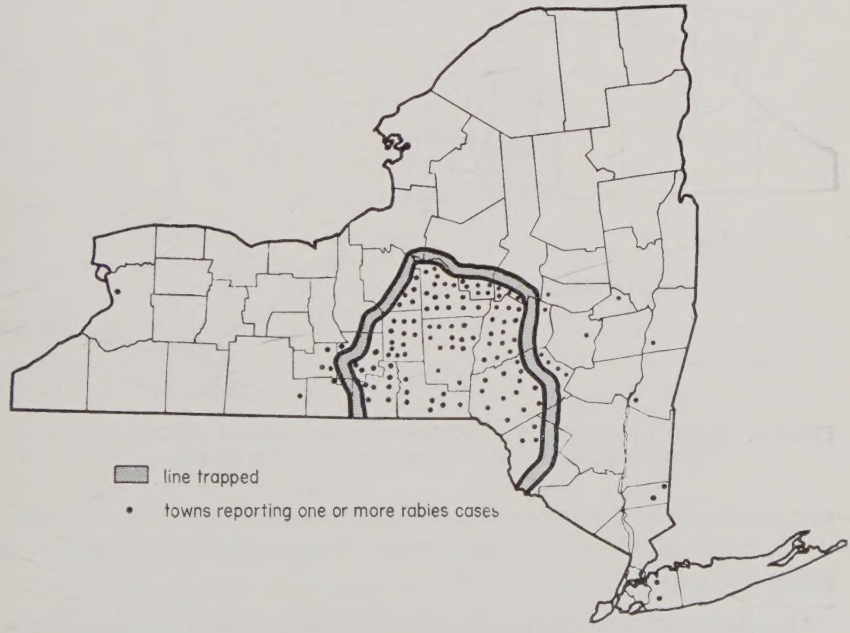

Figure 4. Line (about 5 miles wide) trapped in 1947.

in 1948. This consisted of selecting a series of adjacent towns that would comprise a zone some 15 to 18 miles in depth. In some cases these zones were established on a topographic basis so as to include river basins or a series of ridges. Subsequent zones also incorporated natural barriers to fox movement, such as the Hudson and Mohawk Rivers, the Barge Canal and some of the larger Finger Lakes. As a result of fox dispersal studies by Sheldon (1950), the zones were later widened to approximately 50 miles. Sheldon found maximum fox movement during the "fall shuffle" seldom greater than that. The mean distance traveled was far less.

The purpose of zone trapping was to create a "zone of fox scarcity" such that there would be little chance of a rabid fox from the infected portion of the State encountering and infecting foxes within the zone and thereby spreading the disease. In general, two zones were maintained from 1949 through 1954, one west of the infected portion of the State and the other north of it (Figure 5). During this time little or no trapping

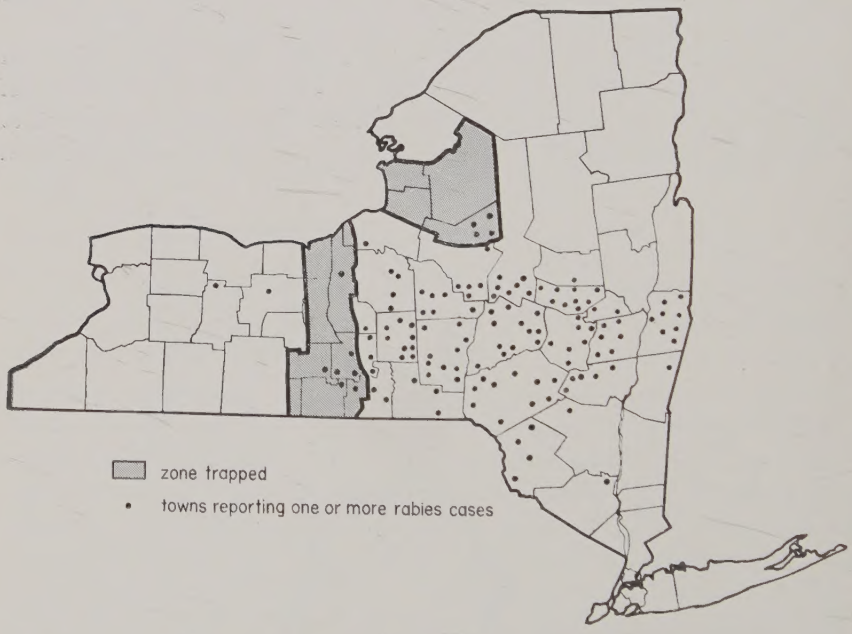

Figure 5. Zones trapped in 1953, outside the rabies-infected portion of the State. The western zone was shifted farther west during the fall.

was done within the infected area to decrease the incidence of rabies there; rather all effort was concentrated in preventing further spread to rabies-free areas.[3]

[3] Colson and McKeon (1952) gave a good description of control methods used from 1946 through 1951.

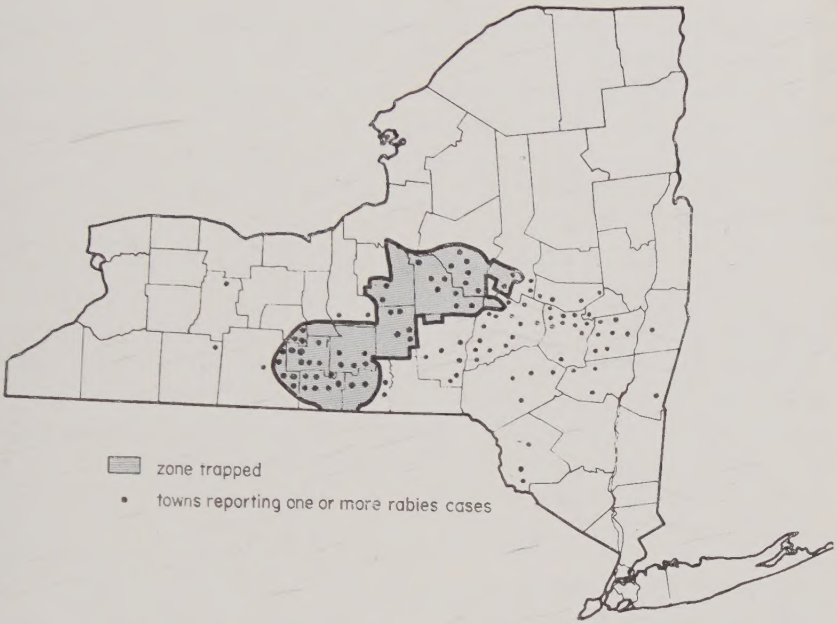

Figure 6. Zone trapped in 1956, within the rabies-infected portion of the State.

In 1955 it was decided to move the zone within the infected area in an attempt to decrease the incidence of rabies as well as restrict its spread (Figure 6). It was anticipated that this continuous zone would be shifted progressively eastward in future years. During 1956 and 1957 it appeared that this modification was somewhat successful. However, in 1958 it became apparent that rabies outbreaks had occurred beyond the zone. In 1959 this situation developed into a severe epizootic which spread westward to Lake Erie and infected areas which had previously been rabies-free. Thus, the effectiveness of this method is not clear.

Parker (1958) stated, "There is a definite indication that fox populations are able to build up following either rabies and/or trapping within two years time to the apparent normal or carrying level of the area." Records of the wildlife rabies control program substantiate this observation. It appears desirable to retrap, every two years, those portions of the endemic area where fox populations have had several years to return to normal density levels following either rabies outbreaks or intensive trapping. Such trapping within the endemic area should serve to reduce the incidence rate of the disease.

Another method, used by State trappers during the spring when fox pups are still confined there, has been gassing known dens with "Cyanogas". These dens are checked the following year and again gassed if in active use. The ease with which dens are located depends somewhat on the predominant type of cover. If an area comprises

extensive wooded tracts rather than being primarily agricultural, locating dens is quite difficult.

Poisons and "Coyote Getters" have been considered as possible aids in controlling rabies in wildlife. However, rabies has generally been restricted to the more populated portions of the State, and it is felt that the use of non-specific poisons would kill many domestic animals as well as beneficial wildlife.

Cost Except during the winter, trapping success is closely correlated with the seasonal movement of foxes. Thus, the largest numbers are taken in the fall when movement is greatest. Similarly, low catches are made in the spring when foxes are confined to denning areas and movement is limited. Records over a 5-year period (1954–1958) show an average of 3,350 taken per year at a cost of about $26 each.

This high cost may be attributed to several factors. In recent years the trapping zones, in order to be most effective, have frequently been located partially or wholly within the periphery of the infected portion of the State. Certain areas within these zones have had low fox populations due to either trapping or rabies outbreaks. Operations in such areas raise the cost per fox. Reduction of a population to the desired level requires that a trapper remain in an area until he catches few animals per unit of effort. The lower the population, the more effective the control. But retention of a trapper in an area until the fox population has been greatly reduced will, of course, increase the cost. Nevertheless, by this method fox populations can be reduced far below the level at which a "bounty trapper" would cease operations.

Census Methods Rabies is a density-dependent disease and tends to spread along avenues of high fox population densities. Comparison of relative densities from year to year may permit predictions as to the future spread of the disease. Some reliable method for determining such densities is needed. Annual censuses might also indicate the effectiveness of trapping in rabies-free areas.

The diverse topographic, vegetative, and land-use patterns in New York State make censusing difficult. A method should be usable during the winter since all trapper effort during other seasons is directed at reducing fox populations. Until 1956, modifications of the roadside track count (Scott, 1941) and the scent-post method (Cook, 1949) were used with varying degrees of intensity and success. When the roadside track count was used most intensively, the method consisted of selecting census lines along back roads, driving these roads for 10 to 20 miles, generally after a fresh snowfall, and tallying the number of fox tracks crossing the road. Lines were usually covered several times a month. Relative indices were expressed as the number of fox tracks per road mile. This method of fixed census lines was applicable to limited areas

only and was found to be subject to considerable error. The scent-post method used during the winter of 1955 consisted of 14 scent-post lines, approximately 30 miles long by 5 miles wide, operated by seven professional trappers. Dirt hole sets, without traps, were established about every 3 miles along the lines. The posts were checked after snowfalls, and an attempt was made to establish an index of relative fox abundance from the number of tracks noted. This method, also, was found to have a considerable degree of error. It was subject to weather conditions and was not applicable over large areas.

Parker *et al.* (1957) devised a technique using the town as a geographic unit. The method consisted of trapping towns to be compared, according to a standard pattern and as nearly simultaneously as possible, for a period of 10 days in the fall. One trap was set per 2 square miles of land area, and traps were placed not less than ½ mile apart. Density indices were expressed as trap nights per fox taken. While it is felt that this method is accurate for comparing population densities, extensive application would require a considerable trapper force and it would be impracticable during the winter.

The method in use at present is comparatively simple. Estimates of relative population density are based on trapper catches the previous year and roadside track counts made during the winter. Back roads are selected with regard to accessibility and topographic features and so as to insure representative coverage of the area. Roads are driven after snowfalls and each track observed is marked on a county map. From the information gathered towns are designated as having low, medium or high fox populations. This method is limited in application and is admittedly subject to many variables. The degree of accuracy in estimating fox population densities and changes is dependent on extensive experience in comparing observed track counts with intensive trapping effort and resultant catches. Data obtained by this technique certainly do not permit exact measurement of densities and density fluctuations, but they are still generally sufficient for making reliable predictions as to population trends. The great advantage is that large areas can be covered easily by a few men during the winter months.

Other Control Programs

Several other control programs are also in effect in the State.

Counties situated in any area in which the existence of rabies in wildlife is certified jointly by the Departments of Health, Agriculture and Markets, and Conservation are eligible for State aid to control this disease. County boards of supervisors may appropriate money to employ trappers to reduce fox populations, and 50 per cent of the amount expended by the county for control measures will be reimbursed by the State. Such trappers work under the supervision of the various district

game managers. In general, this program has not been too successful. County residents and officials tend to ignore preventive control measures and apply for State aid only after a considerable number of rabies cases have been reported from the county.

The game management districts each employ several trappers to handle wildlife damage complaints. These trappers may occasionally be used within their districts for rabies control trapping in the event of severe outbreaks of the disease.

Each year a few counties offer fox bounties. Such bounties have not been effective in controlling rabies in wildlife. They are generally paid for animals which constitute a surplus in the population and do not reduce breeding stock. In addition, many animals are bountied from outside the county or from areas where fox populations are high and where rabies is nonexistent. Catches by State trappers in counties offering bounties have generally been as high as catches where no bounty program was in effect.

State health laws applying to rabies, as well as county programs for compulsory or voluntary dog and cat vaccination, no doubt aid in controlling rabies in wildlife. No data are available; however, it is quite probable that the transmission of the rabies virus from domestic animals (cats and dogs) to wildlife species does occur, although such transmission is certainly not common.

Diseases such as mange have reduced high fox populations in areas where rabies, if introduced, could have resulted in a severe outbreak. Swink[4] estimated that in the Shenandoah Valley (Va.) mange reduced high red fox populations to about 20 per cent of former density levels. Localized reduction of red fox populations by a mange-like disease has also occurred in New York, although it is believed that reductions have not been as great as those in Virginia.

Discussion

The control operations carried on have not eliminated rabies in New York; in fact, they have not been able wholly to prevent its spread. Nevertheless, reduction of fox abundance appears to have reduced the incidence of the disease in the infected portion of the State, and intensive trapping has virtually eliminated it in certain areas for several years at a time. Unfortunately, quantitative data are lacking for precise evaluation. This is especially true with respect to the actual distribution of rabies. The cases reported, while they may reflect the true situation quite accurately for domestic animals, do not do so for its occurrence among wildlife.

[4] S. Nelson Swink, Virginia Commission of Game and Inland Fisheries, personal communication, 1959.

The problem continues to be serious and must be given attention. The concensus of those working on the program and of the Interdepartmental Rabies Committee is that the present approach is the best one available. Its effectiveness, however, could be improved by providing for more trappers so that intensive trapping could be done over a larger area.

County programs employing methods similar to those used by the State have been and will continue to be helpful. So also will dog and cat vaccination. Payment of bounties is not considered worthwhile.

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EFFECT OF SEVIN UPON THE AQUATIC ENVIRONMENT[1]

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ABSTRACT

Sevin (1-naphthyl-N-methyl carbamate) was sprayed by airplane at a rate o 1¼ pounds per acre in fuel oil with a paraffin oil sticker on an area near Oneonta (N. Y.) and its effect upon the aquatic fauna of two streams was studied. Square-foot samples collected before and shortly after spraying showed reductions of from 48.9 to 97.2 per cent in weight of invertebrate fish food. Percentages were computed by the method of Hoffman and Surber (1948) which uses an upstream, untreated station as a corrective. On one stream additional samples were taken nearly a month after spraying, and little recovery could be observed.

The adverse effect was also noted from the large numbers of floating insect nymphs and larvae collected on screens during periods coincident with the passage of water containing spray residues through the various sampling stations. A method is discussed by which this method of sampling could be placed on a quantitative basis.

No mortality among any fish species present in these waters at the time of spraying was observed.

Aerial spraying of forest lands with DDT for the control of gypsy moth infestations has long been practiced. Extending such spraying to inhabited and agricultural lands caused some problems and pointed to the desirability of using an insecticide that would be effective without the adverse effects of DDT.

Early in 1959, the U. S. Department of Agriculture advised this Department that, on the basis of plot and laboratory testing, Sevin (1-naphthyl-N-methyl carbamate) showed promise for controlling the gypsy moth. Information available did not indicate that it would be likely to be toxic to fish life at application dosages. Preliminary studies were reported to indicate it was not transferable to milk and not particularly toxic to warm-blooded animals, including pheasants. It was stated to be quite toxic to bees. There was no information known to be available on its effect on aquatic insects.

Because of the reported effect on bees, and the possible effect on aquatic insects, it was agreed that further study on a test plot was desirable before initiating work on a larger area in New York. The U. S. Department of Agriculture agreed to arrange for such studies in North Carolina on an area that includes a section of a stream. The preliminary report, covering work done in 1959, seemed to indicate little or no determinable effect on aquatic insects, and not too adverse an effect on bees (Morse and Bay, unpublished).

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[1] The authors wish to acknowledge the assistance of W. F. Shepherd and J. N. Shelly of the Norwich Fisheries District of the New York State Conservation Department in the collection of the preliminary field data.

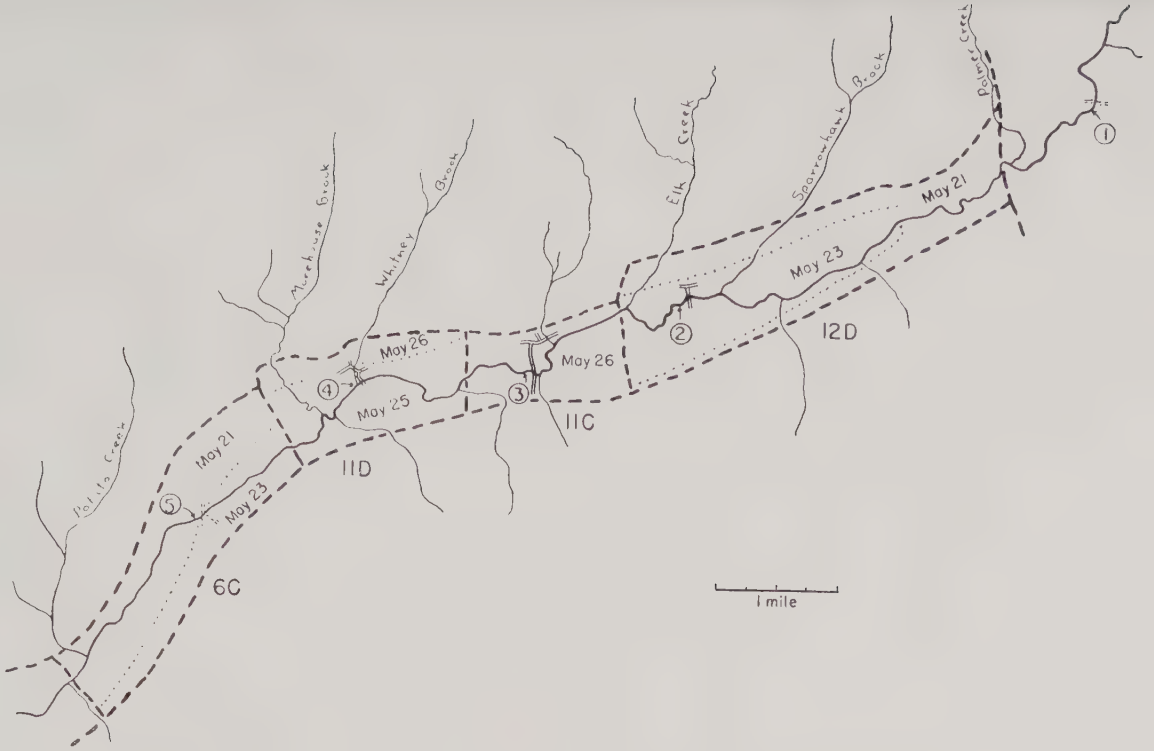

Figure 1. Portion of Schenevus Creek studied showing spraying sections and date each was sprayed; for Sections 6C, 11D and 12D, dotted line separates areas sprayed on different dates only one of which, in each case, had a direct bearing on the sampling done. Numerals in circles indicate location of sampling stations.

In New York a cooperative project was also undertaken in 1959 by the U. S. Department of Agriculture, the State Department of Agriculture and Markets, and the Conservation Department that involved spraying a 75,000-acre area in the vicinity of Oneonta on an experimental basis. This Department was given the responsibility of evaluating any effect on fish and wildlife in this area. The authors' studies were devoted solely to the effect of the spraying on fish and aquatic life.

The scope of this program had to be based on the personnel and time available, and the studies reported here are not as complete or extensive as could be desired. The spraying schedule further reduced the number of streams in which studies could be conducted. Eventually, two streams were chosen: Schenevus Creek, on which the State owned nearly 8 miles of fishing rights in the area to be sprayed; and Kortright Creek, a natural trout stream near the southeastern border of the area. On each, only part of the stream was to be sprayed, permitting an upstream section to be used for comparison. The plan called for spraying in the Kortright area to be done by large planes, while small planes were used in the Schenevus area. Failure of the large planes to operate on schedule prevented sampling in Kortright Creek on the same basis as in Schenevus Creek.

A micronized (additionally ground) suspension of Sevin (95% pure) in No. 2 fuel oil, with a paraffin oil sticker, was used. All brush and trees in the area were to be sprayed. On both streams this required

Figure 2. Portion of Kortright Creek studied showing spraying section, date sprayed and location of sampling stations.

spraying almost the entire length lying in the spray area. The streams were divided into sections, which were sprayed at different times. Figure 1 shows the sections, spraying dates and location of sampling stations on Schenevus Creek, while Figure 2 gives the same information for Kortright Creek.

SQUARE-FOOT SAMPLING

Samples were taken with a Surber square-foot sampler, hand picked in the field, and weighed from 85% alcohol. On both streams pre- and post-spraying samples at each station were collected in close proximity to each other, and the locations were chosen to represent similar physical and rheological conditions. All stations were sampled for the species of aquatic insects present and the quantity of each before spraying. These data served as a baseline for evaluating deviations that resulted from spraying. The pre-spray samples on Schenevus Creek were followed by a similar collection a short time after spraying. Later collections from 22 to 25 days after treatment of the individual sections, were made to assess any recovery. On Kortright Creek, only the pre-spray collections and a sample 13 days after spraying were taken. Data for the two streams are presented in Tables 1 and 2.

Percentages were computed according to the following formula used by Hoffman and Surber (1948) for similar evaluations:

$$100\,\frac{A_2/A_1}{C_2/C_1} = \text{per cent},$$

where A_1, and A_2 are, respectively, the pre- and post-treatment populations in the sprayed area, and C_1 and C_2 are the corresponding populations in the control area. This formula corrects for growth, emergence and recruitment between sampling intervals using the control area as a modifier.

Before spraying, appreciable differences in population existed in different sections of the streams, the poorest occurring in Schenevus Creek below the village of Schenevus and the entrance of its sanitary sewage. The fauna was still poor at the next station below, near Chaseville. Other stations on the stream had a fairly rich fauna, both in terms of weight and number of species. Organisms in Kortright Creek were not as abundant, but the weights were more uniform.

Samples on Schenevus Creek, taken from 1 to 4 days after the section was sprayed, when compared with pre-spray collections, showed reductions of from 48.9 to 92.5 per cent in weight of insect food. Generally, the effect was progressively greater as one went downstream. Station 5 was an exception. While this may have been due to sampling error, it could also have been due to the fact that the water carrying the spray residues from treatment of the section at Chaseville the preceding

Table 1. Square-foot Samples of Aquatic Insects from Schenevus Creek, Associated with Spraying of Sevin in 1959

Item	Station*				
	1	2	3	4	5
Spray section number	§	12D	11C	11D	6C
Date sprayed	.....	May 23†	May 26	May 25	May 23†
Pre-spray samples					
Date	May 19	May 19	May 19	May 19	May 19
Weight (grams)	1.202	0.289	0.290	2.125	1.023
Post-spray samples					
Date	May 25	May 25	May 27	May 27	May 27
Days after spraying	.....	2	1	2	4
Weight (grams)	1.612	0.198	0.104	0.215	0.185
Percentage of theoretical weight‡	.....	51.1	26.7	7.5	13.5
Change (per cent)	.....	−48.9	−73.3	−92.5	−86.5
Samples to determine recovery					
Date	June 17	June 17	June 17	June 17	June 17
Days after spraying	.....	25	22	23	25
Weight (grams)	1.731	0.205	0.195	0.207	0.041
Percentage of theoretical weight‡	.....	49.3	46.7	6.8	2.8
Change (per cent)	.....	−50.7	−53.3	−93.2	−97.2

* Station locations: (1) ½ mile above Schenevus; (2) at Schenevus; (3) at Chaseville; (4) near Maryland; (5) 2 miles below Maryland.

§ This was the control station; through error, one swath was sprayed in this section, but it did not hit the stream at or above the station.

† On May 21, spraying was done in Section 12D 1½ miles above Station 2, and in Section 6C below Station 5.

‡ Calculated after Hoffman and Surber (see text).

day would not have yet reached this station. Support of the latter theory can be found in the fact that the June 17 samples showed this station to contain the least weight of food of any.

These stations failed to show any significant recovery during the period of up to 25 days after spraying. For all but one, the quantity of food was found to be less, on a percentage basis, than at the time of the previous sampling. This was in spite of slightly lower water which at many stations should have crowded the organisms into a smaller compass with an apparent increase in quantity per unit area. No correction has been made for the narrower stream width. The Schenevus Creek samples showed reductions of from 50.7 to 97.2 per cent in weight of

TABLE 2. SQUARE-FOOT SAMPLES OF AQUATIC INSECTS FROM KORTRIGHT CREEK, ASSOCIATED WITH SPRAYING OF SEVIN IN 1959

Item	Station*		
	1	2	3
Spray section number	§	3	3
Date sprayed	.....	June 4	June 4
Pre-spray samples			
Date	May 19	May 19	May 19
Weight (grams)	0.594	0.620	0.757
Samples to determine recovery			
Date	June 17	June 17	June 17
Days after spraying	.....	13	13
Weight (grams)	0.653	0.324	0.051
Percentage of theoretical weight†	.....	47.5	6.1
Change (per cent)	.....	−52.5	−93.9

* Station locations: (1) ¾ mile above spray area; (2) at bridge above East Meredith; (3) ¾ mile above Davenport Center.
§ This was the control station; no spraying was done upstream from it.
† Calculated after Hoffman and Surber (see text).

foods compared with what theoretically should have been present according to the Hoffman and Surber formula (Table 1).

The tendency for the effect to increase at downstream stations would appear to be correlated with the necessity of the organisms to withstand successive passage of slugs containing the chemical, each one of which would have been mixed and diluted before reaching the station. Successive exposure could have produced cumulative toxicity in some of the previously exposed larvae causing the removal of more each time. Since Sevin is reportedly somewhat soluble in water, a high degree of latent toxicity would not be anticipated unless some of the powder was protected from solution by the oil in which it was formulated for application.

On Kortright Creek, preliminary square-foot sampling was not followed by post-spray collections until 13 days after spraying. These showed reductions of from 52.5 to 93.9 per cent in the amount of food present. The greater effect in the downstream area is assumed to have been caused by the increased exposure time to the chemical. This stream was sprayed by one of the large airplanes in one day.

Occasionally, reports on the effect of chemicals on food organisms have been made using the number and types of aquatic organisms present in the sample. Such data are presented in Tables 3 and 4 for these two streams. Identification to family was made by H. J. Dean.

Table 3. Numbers of Aquatic Insects, by Family, in Samples from Schenevus Creek in 1959

Order and family	Station and date*														
	1			2			3			4			5		
	May 19	May 25	June 17	May 19	May 25	June 17	May 19	May 27	June 17	May 19	May 27	June 17	May 19	May 27	June 17
Ephemeroptera															
Heptageniidae	14	1	...	9	5	1	10	...	...	18	3	...	12	2	...
Baetidae	18	46	10	19	5	12	26	13	32	189	12	8	69	15	6
Plecoptera															
Perlidae	1	1	1	...	...	1	...	...	...	...	...	...	...	...	...
Perlodidae	...	...	...	...	...	...	...	...	...	9	...	...	...	...	...
Chloroperlidae	...	...	3	3	...	...	...	...	2	...	...	...	9	...	...
Unidentified	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
Coleoptera															
Parnidae (larvae)	1	2	1	...	...	...	...	2	...	1	1	...	...	...	1
Parnidae (adult)	5	3	1	1	...	...	...	1	6	5	...	1	2	1	...
Psephenidae	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...
Trichoptera															
Hydropsychidae	41	86	74	5	5	20	1	2	10	42	...	7	34	...	6
Rhyacophilidae	...	3	...	...	...	...	...	...	...	...	...	2	...	1	...
Psychomyiidae	...	2	...	...	...	2	...	...	2	...	...	...	...	1	1
Molannidae	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...
Limnephilidae	...	...	1	...	...	...	...	1	...	...	...	2	...	...	...
Unidentified	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...
Diptera															
Tendipedidae	11	18	29	29	6	68	18	1	31	25	23	59	13	5	12
Ceratopogonidae	...	2	...	...	...	...	...	...	...	1	...	3	...	...	...
Simulidae	...	...	...	2	...	1	...	...	2	10	...	1	1	...	1
Rhagionidae	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...
Tipulidae	10	7	10	1	...	...	1	2	...	1	...	...	...	1	...
Tabanidae	...	...	...	...	...	...	...	...	5	...	...	1	...	2	1
Unidentified	...	...	2	...	1	...	1	...	...	...	2	...	...	...	3
Annelida	...	...	...	...	...	...	...	...	...	...	...	...	...	4	...
Megaloptera															
Corydalidae	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...
Sialidae	...	...	1	...	...	...	...	...	...	...	...	...	...	4	...
Total organisms	101	171	141	69	23	105	57	22	90	302	42	84	140	36	31

* See Table 1 for location of stations, relation of dates to spraying, and weights of samples.

Number of organisms is subject to variation from a variety of causes. Elimination of the larger predacious forms, or their hatching and leaving the water, would allow the survival of many more of the newly hatched larvae and nymphs. The number of egg-laying adults available in the area could account for further variation. Species unaffected by the

TABLE 4. NUMBERS OF AQUATIC INSECTS, BY FAMILY, IN SAMPLES FROM KORTRIGHT CREEK IN 1959

Order and family	Station and date*					
	1		2		3	
	May 19	June 17	May 19	June 17	May 19	June 17
Ephemeroptera						
Heptageniidae	3	4	11	..	4	..
Baetidae	24	58	39	13	77	2
Plecoptera						
Perlidae	1	6	..	..	1	..
Perlodidae	..	12	..	1	..	..
Chloroperlidae	4	2	6	..	3	..
Coleoptera						
Parnidae (larvae)	1	3	1	1	..	1
Parnidae (adult)	..	13	..	5	..	3
Psephenidae	4	4	2	3	1	..
Trichoptera						
Hydropsychidae	4	49	3	..	7	..
Psychomyiidae	..	3	..	..	1	..
Limnephilidae	5	4	4	..	..	..
Unidentified	1	..	..	..	..	..
Diptera						
Tendipedidae	6	15	8	12	13	1
Simulidae	1	..	..	..	2	..
Rhagionidae	..	13	..	1	..	..
Tipulidae	1	9	3	..	..	..
Tabanidae	..	1	2	1	..	..
Anthomyidae	..	..	..	1	..	..
Unidentified	..	2	..	..	4	..
Annelida	..	..	..	..	..	2
Total organisms	55	198	79	38	113	9

* See Table 2 for location of stations, relation of dates to spraying, and weights of samples.

sprayed chemical could add greatly to the number of organisms present, even if they had formerly been a minor element in the population.

From a fisheries viewpoint the quantity and availability of food is of major importance. Insects are most available at the time of emergence and egg deposition. Though difficult to measure, elimination of individuals that would contribute to successive hatches during the growing season of fish would adversely affect the productivity of the stream. Replacement by individuals that would not emerge until the succeeding season would not alter significantly the effect on the fisheries in the year of treatment. Even if forage on the crawling insects of a rubble bottom is assumed, total weight consumed is more significant than number. It

is believed that the total weight of organisms in a sample is a more valid parameter of productivity than the number. For this reason Tables 3 and 4 are presented only to show the species composition and not for purposes of analyzing effect on productivity.

SCREEN SAMPLING

Hoffman and Surber (1948) noted that floating insects appeared in a stream shortly after aerial application of DDT and continued for several hours. Jamnback and Collins (1955) noted the same effect, with the additional observation that, at reduced concentrations, only the more susceptible insects (blackfly larvae) appeared to be affected. Both used the bag of a square-foot sampler as a collecting apparatus for the paralyzed and floating insects.

It was believed that insects affected by Sevin would also float downstream and could be collected on screens or in nets. Since the North Carolina studies had apparently shown little or no significant effect on riffle-dwelling bottom organisms, it appeared desirable to use a sampling apparatus which would intercept a larger cross-sectional area of the stream than would the bag of a square-foot sampler which intercepts only one square foot. Increasing area by using screens would result in a larger number of insects being collected and thus improve the possibility of applying statistical analysis.

Plastic screens were fastened in wooden frames made of 2 x 2-inch lumber; they had an inside measurement of 3 x 2 feet. Two ringbolts were inserted on each side to slide over steel stakes driven into the stream bottom to hold the screens in position in the current. A metal ring with a set-screw was then placed over the stake, pushed into contact with the upper ringbolt and tightened to hold the screen in contact with the streambottom. Stakes were driven in a turbulent section of the stream at an angle of approximately 35 degrees from the vertical.

Sets were made at several stations prior to spraying to get an estimate of the normal amount of floating insects present in the stream. Those left in position for periods of from 15 minutes to several hours collected only from zero to seven insects per screen. It was found that floating algae tended to collect on a screen and reduce its porosity so that it became less efficient as a collector. It is doubtful if the results would be quantitative for a period of more than ½ hour, and sets over a longer period of time probably collected no organisms after the first hour. At no time during the pre-spray sampling was there any evidence of a hatch in the stream. During a hatch the number of insects impinging upon the screen would be expected to increase considerably.

It was originally planned to make complete counts on the screen, but the quantity of floating insects appearing after spraying made a total count practically impossible. In swift current there was also some bypass of flow around the ends of the screen. The use of wings placed

parallel with the current could prevent this problem. A counting square superimposed over the screen could then be used to obtain a random count of the insects collected and the data placed on a quantitative basis.

Locations of the screens were established in advance, the stakes driven and the bottom leveled. Screens needed only to be inserted for a fixed period, either for a pre-spray sampling or after oil from the spray was observed at the sampling site. Fllating algae were not so troublesome during the period of sampling after spraying, and the screens acted as collectors for a much longer period of time.

Screens were set at all stations in Kortright Creek prior to spraying and resulted in collections of only five mayfly nymphs at one station. Spraying was postponed, due to unavailability of the proper spray planes until no field personnel were available, so no screen data are presented.

On Schenevus Creek a screen at the control station (#1) was set for 4 hours in a section of stream 45 feet wide, but it became clogged with algae. It collected no insect larvae or nymphs.

The vicinity of Station 2, at Schenevus, was scheduled for spraying on May 21, and the upper mile was actually sprayed. The closest to the sampling station that the stream was sprayed was 2 miles. The area sprayed was not in sight from the sampling station and after spraying had been halted for the day the screens were pulled in the belief no spraying had been done. This resulted in failure to obtain a screen sample to illustrate the effect of the passage of the spray residues through this station. Spraying was continued in this area on May 23 and the screens were reset. Collection during the time oily material was passing the station recovered only seven organisms. In view of the behavior at other stations this can be accounted for only on the assumption that the previous spraying had already eliminated a major portion of the population.

At Station 3, at Chaseville, sprayed on May 26, the screen was set for 15 minutes, replaced with a second screen for 15 minutes, and followed by a third screen for 5 minutes. After a lapse of an hour, a fourth screen was set for 15 minutes. The stream in this location was about 50 feet wide. From the first screen 400 specimens were picked consisting largely of mayflies, caddisflies and stoneflies. It was estimated that nearly as many, if not more, specimens remained on this screen. The second screen was estimated to contain nearly three times as many as the first one; some apparently being of different genera. The third (or 5-minute screen) contained nearly as many insects as the first screen, with some tipulids and tabanids appearing. The last screen, representing a collection from 95 to 110 minutes after treatment, still showed a large number of insects, but not quite as many as were present on the first. The species composition appeared to be somewhat different, with a number of species not present on the first two screens.

The vicinity of Station 4, near Maryland, was sprayed on May 25.

Following completion of the spraying a screen was set in a rapid section of the stream about 30 feet wide and left in position for 20 minutes. Four hundred specimens were picked from this screen and a large number still remained on it. A second screen, replacing the first and left for 15 minutes, showed a more abundant deposition of insects, including some larger and apparently different species. A third screen, set for the succeeding 5 minutes, collected nearly as many insects as the first.

On May 21 a screen was set at Station 5 for 3½ hours. During this period spraying occurred only below the screen location. Examination showed only a single mayfly and a single dipteran larva taken during the period. On May 23 the remaining area of the section was sprayed. A screen placed in position for 30 minutes was picked, replaced for 5 minutes and picked again. An estimated 250 mayflies and caddisflies were removed from the screen. These did not comprise all the organisms on the screen but they were selected as representative of the species composition. Width of the stream at the point of collection was about 30 feet.

While it was impossible to place the screen collections on a quantitative basis, they showed the insect population to have been seriously affected by the chemical. The length of the treated section would influence the length of time that insects would be taken by the screens and the duration of exposure of any insects not collected. The insects collected on the initial screens represented those affected over a section with a flowtime in the stream equivalent to the time during which the screen was in place. Succeeding screens represented the same effect for a similar section, plus any insects affected by the longer exposure in the sections which had been treated previously. The treatment of different sections of this stream was irregular (Figure 1), yet only one station showed any high reduction in the screen collection that could be associated with upstream spraying. This would appear to indicate that there was sufficient dilution or dissipation of the spray in downstream passage that insects in the area below were not always greatly affected by the passage of a slug from upstream.

Residual effect would not be reflected by the screen collections. However, since Sevin is much more soluble than DDT, it is doubtful if any residual deposit would persist for long.

CONCLUSIONS

The data gathered in New York indicate Sevin in oil suspension to be highly toxic to mayflies, stoneflies and caddisflies. Other groups of insects are apparently somewhat less affected over short exposure periods. It is not directly toxic to fishes at the rate of application.

Food production in the sprayed sections of the streams studied was reduced from 50.7 to 97.2 per cent. A progressive effect from upstream

to the lower sections is believed to have been correlated with increased exposure time. The extreme reduction in available food would greatly reduce the productivity of the stream during the same year, if it did not result in migration or starvation of some of the fishes present. Sevin should not be used where the spray can fall on flowing streams if fish production is to be maintained.

LITERATURE CITED

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A STUDY OF SMALL MAMMALS, BIRDS AND OTHER WILDLIFE IN AN AREA SPRAYED WITH SEVIN[1]

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ABSTRACT

The effect of Sevin on small mammals, birds and other wildlife was studied in an area in Otsego County (N. Y.) being sprayed for gypsy moth control. Spraying was done by airplane at the rate of 1¼ pounds of Sevin in a gallon of fuel oil carrier per acre. Data were gathered on four plots selected to represent different types of habitat. Records before and after the spraying were obtained by trapping for small mammals and by observation for other species.

The abundance of small mammals, as well as their condition and reproduction of young seemed unaffected. Observations on 49 species of birds failed to reveal any effect on their behavior, condition or reproduction and rearing of young. Toads, frogs, salamanders and snakes, noted after spraying, appeared to have been unaffected. It was concluded that a single application of Sevin at this rate is probably not harmful to terrestrial wildlife.

In the late spring and early summer of 1959, a study was made of the possible effects of the insecticide "Sevin" on small mammals and other terrestrial vertebrates. The work was done in a portion of Otsego County (N. Y.) that formed a test area for aerial spraying with this chemical as a potential substitute for DDT in the gypsy moth spray program. Sevin has been reported to have a low toxicity for higher animals (see introductory remarks in Burdick, Dean and Harris, 1960), but no field study of its effect on terrestrial wildlife has been reported.

In a sense the study was an extension of a survey of the small mammals in Otsego and Schoharie Counties which had just been concluded.[2] It offered an unusual opportunity, on the one hand, to obtain additional data applicable to the general survey, and, on the other, to make a study of possible toxic effects of large-scale spraying on the animal population in an area from which considerable systematic information had already been obtained. Within the spray area, four plots were chosen, which, insofar as possible, would be suitable for both purposes.

DESCRIPTION OF STUDY PLOTS

Plots were selected to represent several types of habitat. Since population densities were not involved, specific limits were not established.

Plot A

This plot was located on South Hill 1½ miles south of Schenevus at an elevation of 2000 feet. The site was chiefly level and rocky, but it

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[1] The study was suggested by Dr. D. L. Collins, State Entomologist and Principal Scientist, New York State Museum and Science Service-Biological Survey. This paper is published by permission of the Assistant Commissioner, New York State Museum and Science Service, Journal Series No. 37.

[2] An account of this survey is in press as a bulletin of the New York State Museum and Science Service.

was boggy along the northern side and a temporary stream crossed it. The plot was characterized by mixed coniferous-deciduous woods, sugar maple, red maple, beech and hemlock being the common trees except for the wet portion where red spruce and hemlock were dominant. The trees were of various sizes up to about 2 feet d.b.h. for the beech and hemlock and 3 feet for the sugar maple. Over much of it, a fairly dense ground cover of ferns, clubmosses, flowering herbs and young trees occurred. Part of the area was grazed by cattle during the study, while fairly heavy deer browsing was in evidence elsewhere.

PLOT B

This plot, located in dry deciduous woods on Hooker Hill 2 miles south of Westville at an elevation of 2100 feet, had sugar maple and beech as the principal trees, with smaller amounts of basswood and other species. Saplings and small trees were most numerous; larger trees (many about 30 inches d.b.h.) were rather scattered. About half the plot had a ground cover of low sedge (*Carex*); elsewhere there was little ground cover aside from numerous maple seedlings. Some small openings, with growths of blackberries, raspberries and ferns, were present about fallen trees. Coniferous plantations were nearby.

PLOT C

This plot was located on South Hill 1½ miles south of Maryland at an elevation of 1950 feet. It comprised cutover bog and woods edge. Shrubs (blueberries, northern wild raisin, great rhododendron, etc.) made up about 90 per cent of the bog, together with some standing red spruce and red maple as well as numerous old sawlogs and stumps. Sphagnum moss blanketed the wet ground; some tall sedge was also present. The adjacent coniferous-deciduous woods were rich in shrubs and herbs.

PLOT D

This plot was located on South Hill 2 miles south of Maryland at an elevation of 2000 feet. It was on an abandoned farm surrounded by woods, and included both a grassy, weedy field with patches of raspberry and a lower, moist area of sedge, grass, and spirea.

SPRAYING DONE

Plot B was sprayed on May 27; the others on June 11. Sevin was applied at the rate of 1¼ pounds to a gallon of fuel oil carrier per acre.

The amount of insecticide delivered to the various plots may have varied somewhat. The limits of the total area to be treated were changed after trapping was begun, with the result that the Schenevus (A) and

Hooker Hill (B) areas, originally well within the overall region as planned, came to be situated on the borders of it. Although Plot A received the last swath in that locality, and unsprayed territory adjoined it on one side, ground observations indicated that the plot was fully covered with insecticide. Plot B was completely covered with the full dosage, but unsprayed territory was nearby on three sides. Ground vegetation in the open farm habitat appeared to have received a heavier dosage than in the other habitats, including the nearby open bog.

OBSERVATIONS

Data on small mammals were obtained by trapping, using both live traps and snap traps, and records were kept of other animals and birds observed. Information was gathered for each plot both before and after spraying.

Some changes in plan were required during the study. The Hooker Hill area was treated ahead of the originally scheduled time, which resulted in the loss of a week of live trapping that had been planned for Plot B before spraying. The plots on South Hill, on the other hand, were sprayed much later than scheduled because of unfavorable weather and other conditions. On Plot A there was considerable disturbance of live traps by raccoons. In general, the live-trap catch was smaller than anticipated, resulting in relatively few small mammals being marked before spraying.

Since the plots were selected portions of a large more or less "solid" test area of 75,000 acres, and not small, isolated, separately sprayed plots, the data are assumed to be correspondingly more reliable in reflecting the true picture in a large-scale operation.

Small Mammals

On Plot A, 40 small-mammal live traps were operated before spraying (May 5–14). The traps were set in four parallel lines covering roughly 3½ acres (450 x 350 feet). Six chipmunks (*Tamias striatus*), five deer mice (*Peromyscus maniculatus gracilis*), and two woodland jumping mice (*Napaeozapus insignis*) were marked and released. Several shrews taken died in the traps.

This plot was not live trapped again, but a month after spraying (July 7–13) 100 mouse snap traps and 12 rat traps were set along the same trap lines. A rather high population of small mammals was indicated, 79 specimens being taken, as follows: masked shrew (*Sorex cinereus*), 20; smoky shrew (*S. fumeus*), 14; short-tailed shrew (*Blarina brevicauda*), 10; chipmunk, 7; red squirrel (*Tamiasciurus hudsonicus*), 3; northern flying squirrel (*Glaucomys sabrinus*), 2; deer mouse, 14; red-backed mouse (*Clethrionomys gapperi*), 7; house mouse (*Mus musculus*), 1.

Included in the post-spray catch were three of the deer mice and

two of the chipmunks which had been marked in May before spraying. This does not seem too low a proportion of returns considering the time (2 months) that had elapsed after marking and the different method of trapping used. Woodland jumping mice, which were expected, were not taken; however, the small stream along which two were taken in May had dried up by July, and it is possible that individuals of this species had dispersed elsewhere. Breeding was much in evidence. Among the shrews, a high proportion of young was trapped. One chipmunk (a marked individual), one deer mouse, and one red-backed mouse carried embryos, while two deer mice (one marked), two smoky shrews, and one flying squirrel were nursing. The enlarged reproductive organs of many adult male shrews, mice, and squirrels indicated breeding (all five adult male red-backed mice were in breeding condition).

In the woods on Plot B, 20 live traps were set before spraying (May 8–16) in a line about 1,000 feet long. Three chipmunks, seven deer mice, and one meadow mouse (*Microtus pennsylvanicus*) were marked and released. After spraying on May 27, live traps were set again for two short periods: June 9–11 and July 7–8. Five of the marked deer mice and all of the marked chipmunks were retaken (in the two periods together), thus eight of the 11 animals marked before spraying were recaptured after spraying. On the night of July 15–16, 40 mouse snap traps and six rat traps were operated in the same area. Besides the marked animals, the following specimens were taken in the live and snap traps: masked shrew, 1; smoky shrew, 3; short-tailed shrew, 5; chipmunk, 4; deer mouse, 11; red-backed mouse, 1. Young shrews and deer mice were included in the July catch. A female deer mouse marked in May was lactating when recaptured on July 9. Two other females were nursing when taken on July 16, and several males appeared to be in breeding condition on this date.

The bog area on South Hill (Plot C) was not trapped before spraying on June 11. All trapping was done during a short period after spraying: 75 snap traps were set June 15, 30 were added June 17, and all traps were picked up June 18. The traps were set in two parallel lines about 400 feet long. Aside from the masked shrew, small mammals appeared to be low in numbers as, I believe, they were before spraying in this area. Very few new or old signs were detected; e.g., no vole runways or signs were noted. The total catch comprised: masked shrew, 8; short-tailed shrew, 1; deer mouse, 3; red-backed mouse, 1. All these specimens, plus those taken on the farm area (Plot D) on June 17 (total 17) were preserved in frozen condition for possible determination of the presence or amount of insecticide in the tissues.

On the South Hill farm (Plot D) only a small amount of snap-trapping was done, all of it after spraying: 23 traps were set for one night (June 17–18) and 21 for two nights (July 9–11). The catch comprised:

smoky shrew, 1; short-tailed shrew, 2; star-nosed mole (*Condylura cristata*), 1; meadow mouse, 6; woodland jumping mouse, 1; deer mouse, 2; white-footed mouse (*Peromyscus leucopus*), 1. Here, where the insecticide was quite heavy on the grass, fresh meadow mouse sign was fairly abundant in both trapping periods. Adult meadow mice trapped were in breeding condition; the single adult female taken (July 9) was carrying embryos. The woodland jumping mouse, taken 150 feet from its woodland habitat on July 10, had recently finished nursing.

Birds

Table 1 indicates chiefly the breeding species (obvious spring migrants omitted) observed on the areas before spraying (May and June) and after spraying (June and July).

Almost all the common songbirds were as numerous after spraying as before; singing males appeared to be unaffected and were singing in the same places. Actions of the birds, such as carrying food and giving alarm calls, indicated that many species were caring for young in the days and weeks after Sevin was applied. During the month after application, observation of young being fed out of the nest, or beginning to fly, indicated at least some fledgling success for the following species: marsh hawk, ruffed grouse, sapsucker, hairy woodpecker, phoebe, black-capped chickadee, hermit thrush, robin, black-throated green warbler, ovenbird, Canada warbler, towhee, junco, field sparrow, and song sparrow. In the woods, many young ovenbirds in particular were noted being fed. In the farm habitat a marsh hawk nest, with three recently hatched young and three eggs, was found on June 11, the date the area was sprayed. The young seemed unaffected; at least five young were at the nest on July 3, and several flew away when I approached it again on July 15.[3] At the abandoned farmhouse nearby a family of phoebes was observed, and two young were on the wing by the end of the first week of July. On the other hand, there are no data to indicate how many, if any, young birds may have been lost as a result of the spraying done.

Not counting the strictly spring migrant species, in only a few instances were adult birds which were common before spraying not found afterwards, although migrant individuals probably were involved in some of these cases. Nashville warblers were singing on three plots before spraying and were recorded up to June 9, but were not heard after application on any plot, although no special effort was made to locate the species. Rose-breasted grosbeaks were common in May and, on two areas, during early June, but they seemed to vanish (except for a pair

[3] Remains of redwing, meadowlark, and song sparrow fledglings were found at the nest or were dropped by the parents.

TABLE 1. OBSERVATIONS ON BIRDS BEFORE AND AFTER SPRAYING

Species	Plot A	Plot B	Plot C	Plot D
Broad-winged hawk	†		§	
Marsh hawk			§	§
Ruffed grouse	§		†	
Mourning dove	†			
Barred owl			†	
Ruby-throated hummingbird	†		§	
Flicker	§	†	†	
Pileated woodpecker	*	†	§	
Yellow-bellied sapsucker	§	*	†	
Downy woodpecker	*			
Hairy woodpecker		§	†	
Crested flycatcher		†		
Eastern phoebe				†
Traill's flycatcher				*
Eastern wood pewee	†	†	§	
Blue jay	†		§	
Common crow	§		†	
Black-capped chickadee	§	§	§	
White-breasted nuthatch	§	†		
Red-breasted nuthatch	§		§	
Robin	§	§	†	†
Wood thrush	*	§	*	
Hermit thrush	§	†	§	
Veery	†	§	§	
Eastern bluebird				†
Cedar waxwing	†	†	§	
Red-eyed vireo	§	§	§	
Nashville warbler	*		*	*
Magnolia warbler	†		§	
Black-throated green warbler	§	§	§	
Black-throated blue warbler	§	§	§	
Blackburnian warbler	§		*	
Chestnut-sided warbler	§	†		*
Ovenbird	§	§	§	
Northern water-thrush	*			
Yellowthroat	†	†	§	§
Canada warbler	§	§		
American redstart		§		
Brown-headed cowbird	†	†	*	
Scarlet tanager	§	§	§	
Rose-breasted grosbeak	*	§	*	
Indigo bunting				†
Purple finch	§	†	*	
American goldfinch	§			
Rufous-sided towhee	†			†
Slate-colored junco	§	†	§	
Field sparrow				§
White-throated sparrow	§	†	§	
Song sparrow				§

* Species observed before spraying only.
§ Species observed both before and after spraying.
† Species observed after spraying only.

on Plot B) after the spraying was done; late migrants may have been involved. In the bushy farm meadow one (or more) Traill's flycatcher, perhaps a migrant, was calling regularly in early June but was not detected after spraying.

Other Animals

No special search was made for reptiles and amphibians, but some were seen while walking through the plots. Red efts (*Diemictylus viridescens*), wood frogs (*Rana sylvatica*), and American toads (*Bufo terrestris*) seemed quite common during the weeks following spraying; also several garter snakes (*Thamnophis sirtalis*) and, in the farm meadow, pickerel frogs (*Rana palustris*) were noted. Chipmunks were noisy and seemed to be in usual summer abundance in the treated woodlands. Raccoons, deer, woodchucks, and gray squirrels were present in some of the plots in July; on Plot A small fawn tracks appeared early in the month.

CONCLUSIONS

From these data it is believed that a single application of Sevin at the rate of 1¼ pounds per acre is probably not harmful to terrestrial wildlife. No observations were made which would indicate possible long-range effects.

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PELLETED DRY FOOD AS A TOTAL DIET FOR TROUT[1]

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ABSTRACT

The effects of feeding a total diet of pelleted dry foods to brook trout and brown trout were compared with those of a pellet diet supplemented with meat. Nine pairs of hatchery ponds in six hatcheries were used in the experiment which ran from November through April. No significant differences between diets were found for conversion, gain in weight or mortality. The all-pellet ration was found to be more economical in both labor and cost.

Within the last decade a new ration for trout has been developed—the dry food pellet. Prior to this, hatchery trout were fed ground meat or ground meat with fine-ground, dried cereals and animal products added. Both of these rations are expensive to buy and prepare as well as cumbersome to handle. New York State has been using dry meals as components of trout diets for over 20 years. In 1951 it started using pellets of Cortland dry meal mixture (No. 6 formula).[2] There has been no agreement among the hatchery foremen as to what percentage of pellets should be used in the total diet. The same lack of agreement is found throughout the United States in commercial, State and Federal trout hatcheries. Both success and failure have been reported for all-pellet diets.

There are several commercial pellets on the market which their manufacturers claim to be complete for trout. The formulae for these products are "closed", i.e., the ingredients and their amounts are not listed. Since New York State fish hatcheries are supported by public funds, fish food must be purchased by competitive bidding, and bids must be accompanied by a list of ingredients giving both qualitative and quantitative specifications. The manufacturers refuse to do this. Therefore, it was considered economically essential to find how nearly 100-per cent use of pellets prepared according to the State's own formula could be approached.

The pellet formula as used in the experiments reported here is given in Table 1. Since the completion of this study, the amount of distiller's solubles has been increased from 17 to 21 per cent and dry skim milk has been reduced from 7 to 3 per cent. This was done to bring the total grain products in the formula to 60 per cent and so obtain a cheaper carload freight rate with no loss of nutritional qualities.

Grassl (1956) found that dry-food pellets with no raw-meat supplement could be fed for at least a 3-week period without affecting the growth rate adversely. He reported that the conversion was cut in half as com-

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[1] Grateful acknowledgment is made to David C. Haskell for statistical analysis of the data.

[2] Comprising 24 per cent wheat middlings, 24 per cent whitefish meal, 24 per cent cottonseed meal, 24 per cent dry skim milk and 4 per cent salt.

Table 1. Formula for New York State Dry Food Pellet for Trout

Ingredient	Per cent	Composition	
		Item	Per cent
Wheat flour middlings (Red Dog or equal quality)	24	Protein Ash Fat Fiber	15 2.5 4 2.5–3
Whitefish meal (finely ground)	24	Protein Fat Moisture	60 (minimum) 6 (maximum) 10 (maximum)
Cottonseed meal	15	Protein Fat Crude fiber Carbohydrates	41 (minimum) 5 13 (maximum) 25
Dry skim milk (roller process)	7	Protein Fat Carbohydrates Ash Moisture	34 (minimum) 1 (maximum) 50 8 7 (maximum)
Dry brewers yeast (non-debittered)	10		
Distillers solubles	17	Protein Fat Fiber Lactic acid Nitrogen free extract Minerals Moisture	22–32 3– 8 2– 4 9 (maximum) 51–54 7– 9 2– 5
Cod liver oil	3	Vitamin A (U.S.P.)—2,250 units per gram (minimum) Vitamin D (A.O.A.C.)—300 units per gram (minimum)	

pared with that for an all-meat diet. In Quebec, Seguin (1956) showed that a pelleted dry food when fed with meat produced better results than did a meat-diet supplemented with meal. Brockway (1952) compared a commercial pellet and the New York pellet for two years with excellent results in both cases. Willoughby (1952) fed pellets six days per week and meat one day per week over a 5-month period and attained a conversion of about one-half that for an all-meat diet. In Minnesota, Schumacher (1958) reported good results from feeding an all-pellet diet as compared with a meat diet supplemented with meal over seven 31-day periods.

METHODS AND MATERIALS

The test fish chosen were yearling and 2-year-old brook trout (*Sal-*

velinus fontinalis) and brown trout (*Salmo trutta*). They were held at normal densities (not exceeding 2 pounds of fish per cubic foot of water) in 18 ponds at six hatcheries. The fish in nine ponds were fed only pellets; the others were fed the regular hatchery diet of pellets with meat supplement (Table 2). There was variance in the standard diet among hatcheries.

TABLE 2. PERCENTAGE COMPOSITION OF DIETS USED FOR CONTROL GROUPS OF TROUT AT THE DIFFERENT HATCHERIES*

Hatchery	Pellets	Beef liver	Pork spleen	Frozen shrimp heads§
Adirondack	27	10	47	16
Crown Point	26	13	33	28
Johnstown	0	37	37	26
Lake George	36	19	45	0
Rome				
Yearling	53	0	47	0
2-year-old	63	0	37	0
Warrensburg	41	14	21	24

* Salt (1 to 2 per cent) was added as a binder to the meat and meat-shrimp portions of the diets.
§ Shrimp was fed to the brook trout to improve their coloration.

The fish were fed according to the New York State Feeding Chart (Deuel *et al.*, 1952). Meat was fed at the 100-per cent level; pellets were fed at the 50-per cent level. A misunderstanding led to the fish at the Crown Point Hatchery being fed pellets for the first three months at the 100-per cent level, which has been demonstrated to be much too high.

RESULTS

The experiment was started in November 1957 and terminated April 30, 1958. The data are summarized in Table 3. With respect to the number of days the experiment was in progress at each hatchery, the variation in time between the experimental and control lots was small enough to be ignored in the calculations. Since there will always be temperature variations among hatcheries, no effort was made to assess differences on this basis.

GAIN IN WEIGHT

While there were wide variations in percentage gain between hatcheries, principally due to temperature, differences within hatcheries were

Table 3. Results of Experiments in Feeding All-pellet Diet to Trout

Hatchery and group*	Weight in pounds			Gain in per cent	Mortality in per cent	Conversion	Cost per pound		Number of days
	Start	End	Gain				Food fed	Fish gain	
Brook trout									
Adirondack									
Pellet-fed	730	1,127	397	54.4	3.9	3.2	0.0822	0.26	151
Control	792	1,237	445	56.2	2.0	3.9	0.1125	0.44	151
Crown Point									
Pellet-fed	990	1,384	394	39.8	4.6	6.3	0.0822	0.52	151
Control	987	1,645	658	66.7	2.5	4.9	0.1107	0.54	151
Johnstown (2-year-olds)									
Pellet-fed	768	1,012	244	31.8	15.0	3.4	0.0822	0.28	121
Control	768	907	139	18.1	12.7	13.8	0.1282	1.77	121
Warrensburg									
Pellet-fed	478	1,143	665	139.1	2.5	2.1	0.0822	0.17	162
Control	487	1,118	631	129.6	5.6	3.5	0.1030	0.36	162
Brown trout									
Lake George									
Pellet-fed	932	1,660	728	78.1	1.8	2.8	0.0812	0.23	151
Control	979	1,994	1,015	103.7	0.9	3.3	0.1082	0.36	151
Rome (yearlings)									
Pellet-fed—Lot 1	1,615	1,891	276	17.1	0.0	4.3	0.0822	0.35	123
Lot 2	1,614	2,050	436	27.0	0.0	3.1	0.0822	0.25	130
Control —Lot 1	1,620	1,979	359	22.2	0.0	3.9	0.0903	0.35	121
Lot 2	1,606	1,925	319	19.9	5.6	4.6	0.0989	0.45	122
Rome (2-year-olds)									
Pellet-fed—Lot 1	1,125	1,495	370	32.9	5.1	3.9	0.0822	0.32	171
Lot 2	1,371	1,586	215	15.7	14.0	6.7	0.0822	0.55	146
Control —Lot 1	1,321	1,626	305	23.1	7.7	4.8	0.0959	0.46	172
Lot 2	1,359	1,459	100	7.4	13.0	13.2	0.0959	1.26	165

* All groups were comprised of yearlings except as noted.

relatively small. The sum of the percentage gains of all control lots was 447.1; for the experimental lots, 435.9. Analysis of variance showed the difference to be not significant ($F = 0.05$). On the basis of this experiment it can be expected that an all-pellet diet will produce the same gains as will a meat-supplemented diet.

Mortality

Mortality percentages were based on inventory differences between

the start and end of the experiment. The values appear quite high, but it should be noted that they represent a 4- to 5-month period.

The three lots at Rome for which no mortality is listed had an overrun on final inventory indicating errors in initial or final counts. Since both control and experimental lots had overruns, no attempt was made to adjust the figures. Total percentage mortality for all experimental lots was 46.9; for the control lots, 50.0. Analysis of variance showed the difference to be not significant ($F = 0.06$).

In order to keep the experimental times nearly even among hatcheries, the data were terminated April 30 since in most cases the fish were being shipped by that time. However, both lots at the Lake George Hatchery were continued during May with a very interesting development. The experimental lot began to break down and its mortality rose rapidly. On May 11 these fish were put on a meat diet consisting of 50 per cent pork spleen and 50 per cent beef liver. Response was immediate; mortality was halted and the fish made a good gain for the remainder of the month. During this experiment at least, a limit for continuous pellet feeding was reached. Any broader conclusion must await repetition of the experiment.

A few of the fish that died during this period of high mortality were preserved in formalin and sent to the Fish Pathology Laboratory at Rome (N. Y.). No specific breakdown in any of the tissues could be found. It is possible that freshly dead or dying specimens would have exhibited anemia.

CONVERSION

Food conversions were calculated by dividing the pounds of food fed during the experiment by the pounds of fish gained. The average conversion for all pellet-fed lots was 4.0, and for the control lots it was 6.2. Analysis of variance showed the difference to be not significant ($F = 2.55$).

Neither of the above conversions are favorable; they were considerably in excess of the annual statewide hatchery conversion of 3.5 for the 1957–58 year in which the experiment was done. The trials were conducted during the winter months when conversions tend to be somewhat higher than average.

It has been conjectured for some time that the Feeding Chart values are too high in the temperature range below 40° F., and all of the fish, except those at the Warrensburg Hatchery where the conversions were substantially less, were in this range for much of the experiment. Consequently, the fish on both diets were probably overfed for a portion of the time.

Food Costs

The all-pellet diet cost $8.22 per 100 pounds, and the food cost per pound of fish gained was 32.9 cents. The meat-supplemented pellet diet cost $10.50 per 100 pounds; the food cost per pound of fish gained was 65.2 cents—twice that realized when pellets alone were used. As was mentioned in the comments on conversions, these figures are higher than could reasonably have been expected.

CONCLUSION

Any possible advancement toward an all-pellet diet will markedly decrease food costs for rearing trout. This experiment suggests that New York State trout hatcheries could feed such a diet to yearling brook trout and brown trout from November through April.

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EFFECT OF SORTING BROWN TROUT ON SEX RATIO AND GROWTH[1]

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ABSTRACT

Unsorted samples of brown trout fingerlings had an approximately 50:50 sex ratio. Length and weight data according to sex for a small group of brown trout were taken over a period of a year. The rate of growth, as measured by increases in length or in the cube root of the weight, was found to be nearly the same for males and females. It was nearly the same for the groups produced by sorting. Although the average growth rate was approximately the same for groups of different size, great variation was observed among individual fish, so that the effect of sorting was only temporary in producing groups of uniform size. Selection of the largest fish by length or weight at a given age was found to have little value in predicting their subsequent growth rate.

A study of the comparative growth among the sexes of brook trout was reported by Haskell and Griffiths (1956). Similar data have been collected for brown trout. The sample used was taken from a lot of brown trout fingerlings from the Randolph Hatchery on September 20, 1956. By sorting and resorting with bar sorters these fish were separated into four groups. Each fish was then individually tagged with a jaw tag, and its weight and length were measured. These groups were then put together and held under hatchery conditions until September 25, 1957. Individual weights and lengths were taken at intervals, and sex was determined either at the time a fish died or at the end of the experiment. From those fish which survived to the end of the experiment, random selections were made to obtain a sample in which each sex in each group appeared in the same proportion as in the original groups. The number of each sex in the four groups is given in Table 1. This paper covers an analysis of the growth of these four groups of brown trout.

The experiment was handicapped by a tremendous loss of tags among these fish. The losses resulted from erosion of the jaw until the bone was worn through. This caused a very considerable reduction in the number of fish, so that the final conclusions are based on only about half the original numbers.

GROWTH AS MEASURED BY LENGTH

In Figure 1, the mean length of each of the four sorted groups is plotted against time, the data being the mean length of each group on

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-11-R.

[2] Now a graduate student at Cornell University.

Table 1. Sex Composition of Four Sorted Groups of Brown Trout

Group	Number of fish	Number	
		Male	Female
1 (largest)	34	17	17
2	34	17	17
3	25	11	14
4 (smallest)	31	12	19
Total	124	57	67

four dates spread throughout the experiment. It will be noted that the four lines are nearly parallel throughout.

In Figure 2, the mean length of each sex is similarly plotted. The difference was consistently small. In contrast, among the brook trout of the previous experiment the males were slightly larger at the start and gradually increased their lead.

GROWTH AS MEASURED BY WEIGHT

The same comparisons of growth have been made using average weight instead of length. Figure 3 shows the growth rates of the four sorted groups, and Figure 4 the growth of the two sexes. For the sorted groups, the weights diverged quite rapidly indicating, by this measure, that the growth of the larger fish was more rapid. For the sexes, the males were slightly heavier at the start and gradually increased their lead.

GROWTH AS MEASURED BY CUBE ROOT OF MEAN WEIGHT

Figures 5 and 6 give the growth of the four groups and of the sexes, respectively, according to the cube root of the mean weight. The similarity between these and the data for length (Figures 1 and 2) is striking. All of the conclusions drawn for length seem to apply here as well. In both instances, it appears that the larger fish did not have a faster growth rate than the smaller ones; in fact they were nearly equal.

INCREASES IN LENGTH OF INDIVIDUAL FISH

In Figure 7 increases in length of individual fish are plotted against their initial lengths. The top part of the graph represents the first period; the middle part, the first two periods; the bottom part, the entire time of the experiment. These data indicate that, based on this lot of brown trout, the rate of length increase in a future period is not influenced by the present size of the fish. The largest fish at a given time did not grow most rapidly after that. This agrees with the conclusion reached by Haskell and Griffiths (1956) for brook trout, and leads one to strongly suspect that for trout, the rate of growth of an individual for a short

Figure 1. Growth of four sorted groups of brown trout according to the increase in the mean length of each.

Figure 2. Growth of the two sexes of brown trout according to the increase in the mean length of each for the four groups combined.

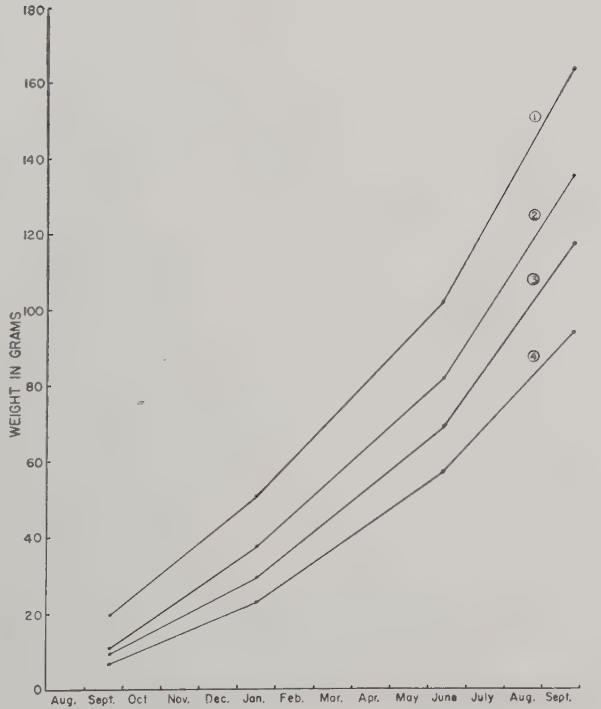

Figure 3. Growth of four sorted groups of brown trout according to the increase in the mean weight of each.

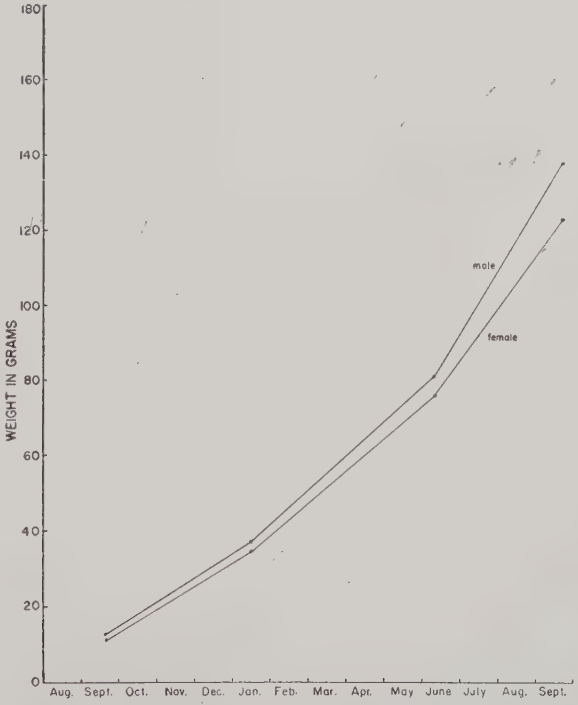

Figure 4. Growth of the two sexes of brown trout according to the increase in the mean weight of each for the four groups combined.

Figure 5. Growth of four sorted groups of brown trout according to the increase in the cube root of the mean weight of each.

Figure 6. Growth of the two sexes of brown trout according to the increase in the cube root of the mean weight of each for the four groups combined.

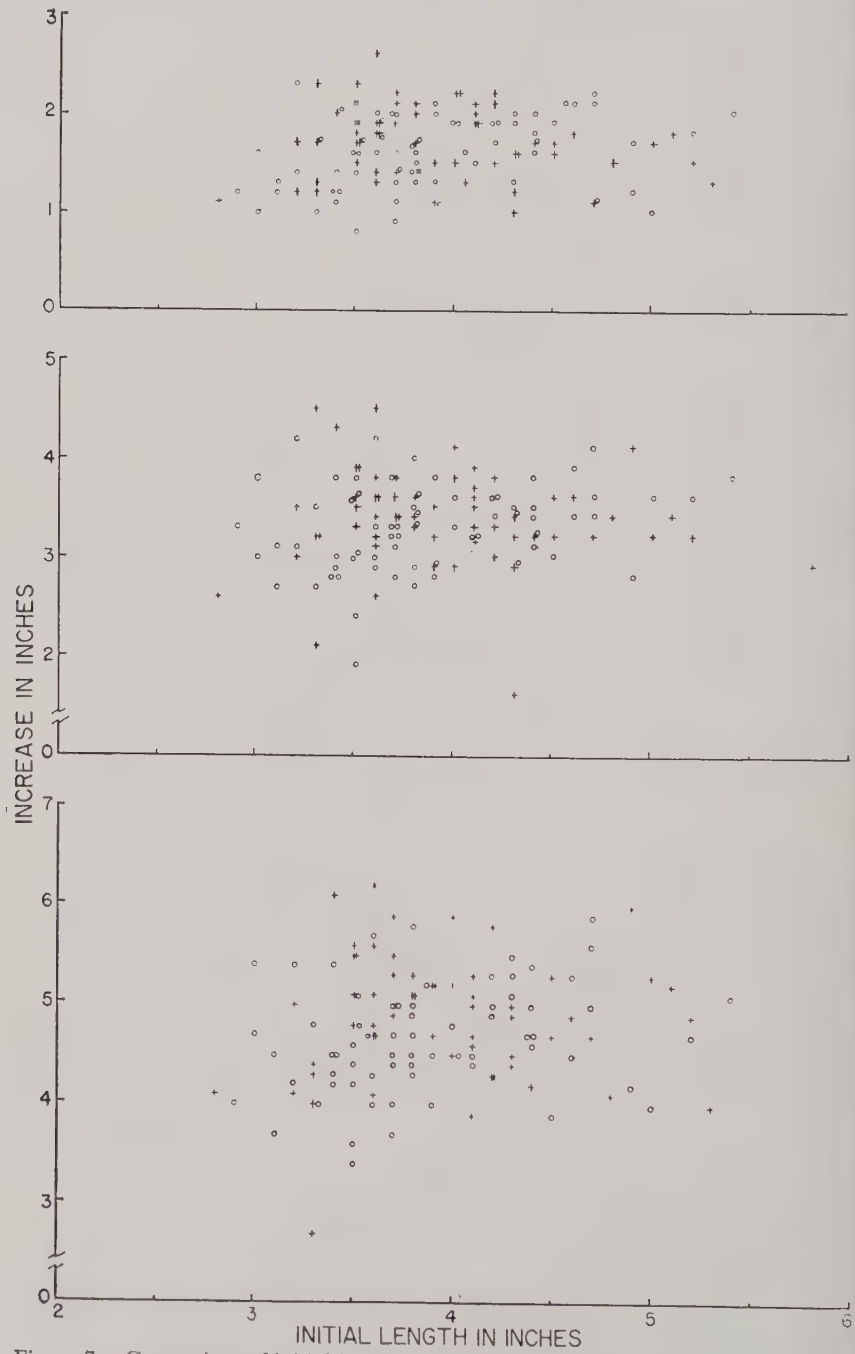

Figure 7. Comparison of initial length of brown trout fingerlings (on September 26, 1956) with their subsequent increase in length: (top) to January 16, 1957; (middle) to June 12, 1957; (bottom) to September 25, 1957. (+ = male; o = female).

period as measured by length is entirely random and follows the laws of chance. As a result, it is only when a group of fish is considered as a unit, that a uniform growth rate appears. This finding is of importance to the producing hatcheryman since, if he should, for some reason, select the "runts" of a group for future rearing, his gains and production should in no way suffer. These small fish will, on the average, grow at the same rate as did the entire lot earlier when its average size was comparable.

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CANVASBACK ABUNDANCE IN NEW YORK[1]

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ABSTRACT

Aerial census records are summarized with respect to the distribution and relative abundance of canvasbacks in New York from 1949 to 1959. Long Island, Lake Ontario and the Central Lakes were the regions of the State most used by this species. Trends in abundance varied considerably between regions. Also, when the data for New York were compared with midwinter inventory figures for the Atlantic Flyway as a whole and for the Mississippi Flyway, wide discrepancies were evident. Canvasback abundance in New York did not reflect the decline indicated by data from elsewhere. It is concluded that the weight of evidence at the present time does not justify relaxing hunting regulations.

For more than 10 years, the distribution and relative abundance of waterfowl in New York have been recorded, chiefly by aerial censusing. The time and number of flights and the routes of travel have been previously described (Benson *et al.*, 1957). In past studies of the data recorded, the major groups—marsh ducks and diving ducks—have been considered primarily, rather than individual species. An apparent national decline in canvas-back (*Aythya valisineria*) numbers (Crissey, 1958) has focused attention on this species. For this reason it appears worthwhile to appraise the records for it.

The aerial census records fall into two main categories, i.e., midwinter data taken each January from 1949 through 1959, and fall data for 1948 through 1953 and for 1957. In both cases they represented the same regions of the State—Long Island, Hudson Valley, Lake Champlain, Ontario-St. Lawrence, Lake Ontario and Central Lakes.

MIDWINTER DATA

The midwinter data are summarized in Table 1. They indicate that only three regions of the State regularly harbor appreciable wintering flocks—Long Island, Lake Ontario and the Central Lakes. The Champlain and Hudson Valleys were little used, and the Ontario-St. Lawrence region, while it often attracts canvas-backs during the fall, was not usually a wintering area.

Examination of the locale of the records within each region indicates a moderately high agreement from year to year in the waters used. In the Long Island region most of the canvasbacks were observed at the

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-39-R. The writers are indebted to John Schempp and Edward Maunton who collected most of the aerial records.

TABLE 1. REGIONAL DISTRIBUTION OF CANVASBACKS OBSERVED ON MIDWINTER AERIAL CENSUSES FROM 1949 TO 1959

Year	Long Island	Hudson Valley	Lake Champlain	Ontario-St. Lawrence	Lake Ontario	Central Lakes	Total
1949	1,200	58	0	0	1,125	1,755	4,138
1950	603	40	0	0	1,075	794	2,512
1951	366	30	0	0	2,450	1,761	4,607
1952	735	0	0	0	7,300	2,733	10,768
1953	680	185	0	50	6,790	1,015	8,720
1954	5,295	0	0	420	14,130	3,524	23,369
1955	845	290	0	85	11,840	2,720	15,780
1956	1,933	10	10	0	4,507	8,085	14,545
1957	2,065	0	0	170	10,419	13,278	25,932
1958	9,690	0	15	1,250	8,970	8,678	28,603
1959	5,230	0	70	390	3,704	5,273	14,667
Average	2,604	56	9	215	6,574	4,511	13,967

TABLE 2. DISTRIBUTION OF CANVASBACKS OBSERVED ON MIDWINTER AERIAL CENSUSES IN THE CENTRAL LAKES REGION AND ALONG THE NIAGARA RIVER FROM 1949 TO 1959

Locality	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Central Lakes											
Canandaigua	200	20	135	339	150	940	287	1,125	2,015	1,109	450
Seneca	530	10	200	898	500	2,160	1,500	5,505	7,725	2,767	3,465
Cayuga	1,025	740	75	726	253	24	335	1,455	2,920	3,532	1,085
Keuka	—	4	350	350	100	400	106	—	208	1,183	190
Conesus	—	20	—	—	—	—	—	—	—	—	—
Owasco	—	—	1,000	20	12	—	—	—	75	75	2
Skaneateles	—	—	1	400	—	—	492	—	335	12	81
Total	1,755	794	1,761	2,733	1,015	3,524	2,720	8,085	13,278	8,678	5,273
Niagara River											
Lower River	—	—	100	—	—	1,300	625	500	500	1,000	1,100
Grand Island	1,025	1,075	2,300	7,300	6,725	12,510	10,820	3,700	9,500	7,170	2,350
Total	1,025	1,075	2,400	7,300	6,725	13,810	11,445	4,200	10,000	8,170	3,450

western end along the northern shore, while the species was rarely seen east of Port Jefferson. On the southern shore most observations were made in Jamaica Bay with occasional records east to Moriches Bay.

Upstate, the larger Finger Lakes (Canandaigua, Seneca and Cayuga) and the Niagara River were the consistently important wintering areas. When relatively free of ice, Keuka, Owasco, Skaneateles and Conesus Lakes also attracted small flocks. Seneca Lake usually held the greatest

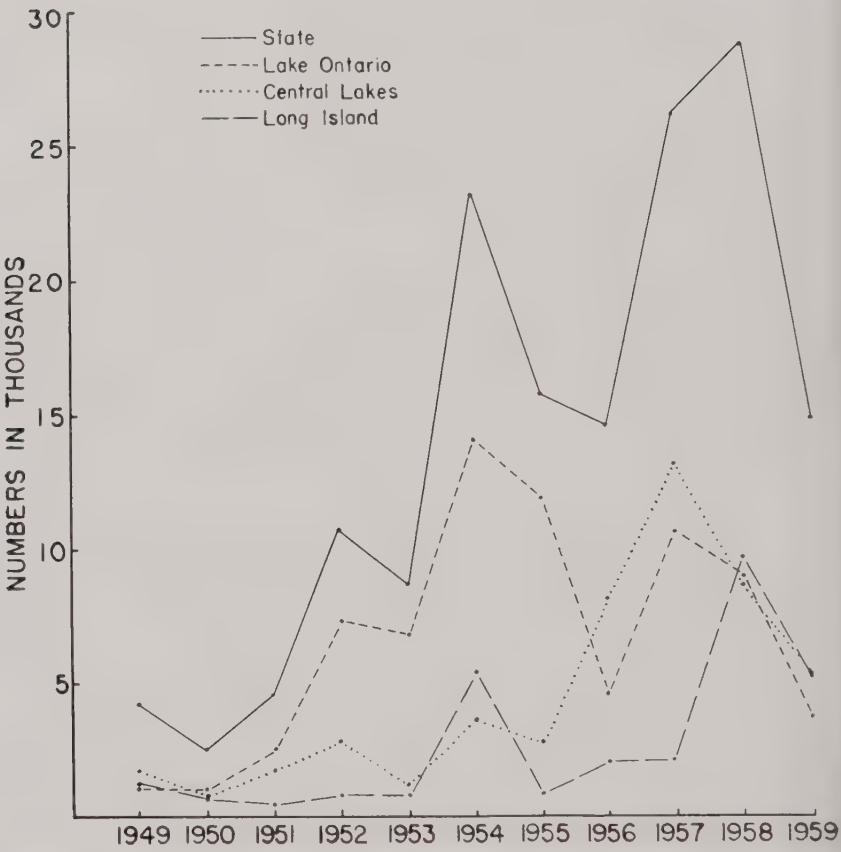

Figure 1. Canvasbacks observed during midwinter aerial censuses for the State as a whole and the three major wintering regions from 1949 to 1959.

numbers (Table 2). During five of the 11 years the Finger Lakes population exceeded that of the Niagara River, but for the entire period the numbers using the Niagara River averaged 40 per cent greater. Occasionally, a few wintered along the southern shore of Lake Ontario near Rochester, Sodus Bay and Oswego. Records from the Ontario-St. Lawrence region showed an occasional flock near Henderson Harbor or on the St. Lawrence River. Scattered individuals or small flocks might be seen in almost any of the larger waters of the State along with other wintering waterfowl. Both field observations and banding records indicated that these wintering flocks were not completely sedentary and that movement from one lake to another was frequent.

Study of the midwinter data showed only a partial inter-relationship between fluctuations in canvasback abundance for the different regions and that for the State as a whole. Two types of relationship were looked for—one in which the fluctuations for all regions directly paralleled that

for the whole State, and one in which the fluctuation in one region was inverse and compensatory to that in another. The data for the three main wintering regions and the State as a whole are plotted in Figure 1.

Canvasback abundance in these three regions and for the State increased in 1952, 1954 and 1957, and decreased in 1950, 1953, 1955 and 1959. The degree of change was negligible for Lake Ontario in 1950 and for Long Island in 1953 and 1957. For the other years the trends were divergent, but in two of them (1951 and 1958) the trends for the Lake Ontario and Central Lakes regions appeared to be in general agreement and opposed to that for Long Island. In all regions the annual variations from the average were very great.

Data for the Atlantic Flyway, as summarized by the U. S. Fish and Wildlife Service (Addy, 1958), are compared with those for New York in Table 3. Both showed increases in canvasback abundance in 1952

TABLE 3. COMPARISON OF THE NUMBERS OF CANVASBACKS OBSERVED ON MIDWINTER AERIAL CENSUSES IN NEW YORK WITH THOSE RECORDED FOR THE ATLANTIC AND MISSISSIPPI FLYWAYS FROM 1949 TO 1959 AND THE VARIATION FROM THE 11-YEAR AVERAGES

Year	New York			Atlantic Flyway		Mississippi Flyway	
	Number observed	Variation (per cent)	Percentage of flyway total	Number observed*	Variation (per cent)	Number observed*	Variation (per cent)
1949	4,138	− 70	2.1	195,000	− 13	80,000	− 7
1950	2,512	− 82	1.3	200,000	− 10	70,000	−19
1951	4,607	− 67	3.3	140,000	− 37	55,000	−36
1952	10,768	− 23	5.1	210,000	− 6	100,000	+16
1953	8,720	− 38	2.4	370,000	+ 66	90,000	+ 5
1954	23,369	+ 67	5.2	450,000	+102	85,000	− 1
1955	15,780	+ 13	5.4	290,000	+ 30	100,000	+16
1956	14,545	+ 4	6.5	225,000	+ 1	70,000	−19
1957	25,932	+ 86	14.8	175,000	− 22	110,000	+28
1958	28,603	+105	28.6	100,000	− 55	100,000	+16
1959	14,667	+ 5	15.9	92,000	− 59	Not available	
Average...	13,967	xxx	6.3	223,000	xxx	86,000	xxx

* Only approximate figures as interpreted from graphs prepared by Addy (1958).

and 1954, and decreases in 1955, 1956 and 1959. The relationship was inverse for the other five comparable years. Similarly, in only five of nine years was the State trend in the same direction as that reported for the Mississippi Flyway. In only two years did all three values fluctuate together—up in 1952 and down in 1956.

This seeming inconsistency may have been due to birds from Lake St. Clair and Lake Erie occasionally moving into New York where they were counted in the Atlantic Flyway inventory rather than in that for

the Mississippi Flyway. A few thousand canvasbacks invading western New York in late December might have little effect on the total Mississippi Flyway population, and would not appreciably swell that of the Atlantic Flyway, but the number wintering in New York would be increased greatly. Stewart *et al.* (1958) suggested that such shifts between flyways do occur.

Over the 11-year period the average number of canvasbacks observed in New York was about 6 per cent of that reported for the Atlantic Flyway as a whole. However, the proportion varied strongly from scarcely more than 1 per cent in 1950 to over 28 per cent in 1958.

Another approach to evaluating the interrelationship of State and flyway records is to use the variation from the respective 11-year averages. In 1949, 1950, 1951 and 1952 both were below average, and in 1954, 1955, and 1956 both were above average. Thus, only in four years were the variations inverse. For most years the degree of variation was sharper

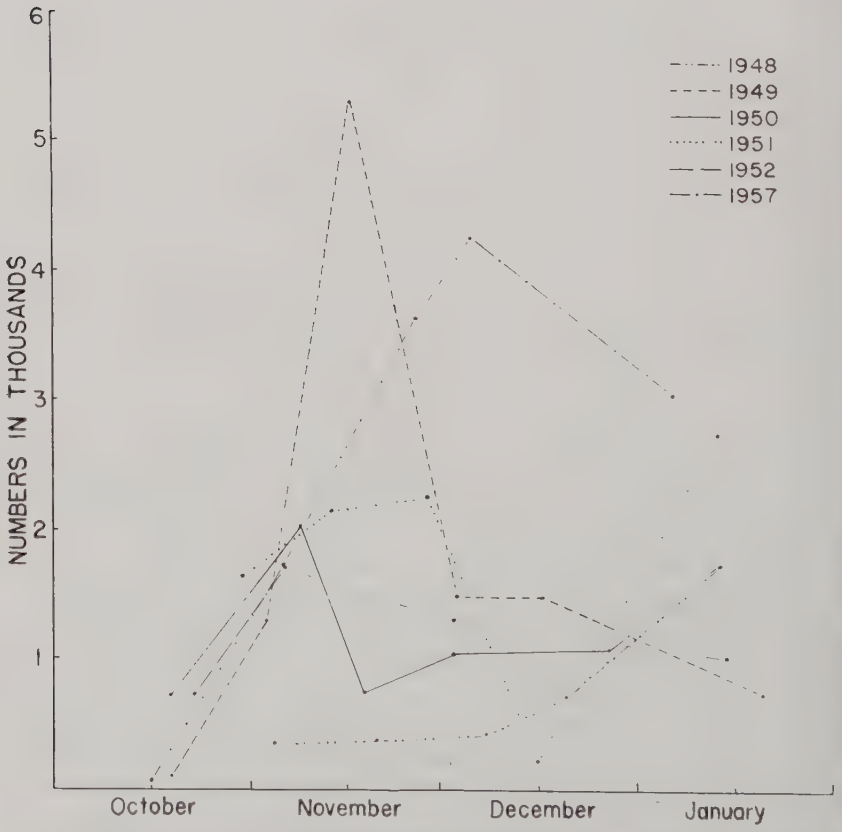

Figure 2. Fluctuations in canvasback abundance during the fall in the Central Lakes region as indicated by aerial-census records for the years 1948 to 1952 and 1957.

in the State records than in those for the flyway, but not enough to suggest that the flyway records were any more reliable than those for the State.

These midwinter data, therefore, indicate that there must be differences in the degree of canvasback concentration from one year to the next, not only from area to area and state to state, but probably from flyway to flyway also.

FALL DATA

The fall data from aerial census records of canvasback abundance do not lend themselves to direct tabulation because in the different years it was not always possible to make the various flights on comparable dates. To eliminate this problem the data are presented in graph form (Figures 2–5).

The data are quite variable. Only in the Central Lakes region (Figure 2) did they suggest a pattern, but it was not consistent. There the numbers rose rapidly in late October and early November to reach a peak which occurred as early as November 6 (1952) or as late as December 5 (1957). After this peak a dip occurred in late November or early December, and was followed by a gradual rise in early January during two years (1950 and 1951). In 1949, 1952 and 1957 there was no rise following the migration peak. In 1948 there was no fall peak and the maximum number was observed in January. In 1951 the January peak was greater than the one in November so that only in these two years (1948 and 1951) did the January numbers exceed those for migration season.

In the Lake Ontario region (which in this instance applies primarily to the Niagara River) canvasback abundance showed a very different pattern with the buildup coming in December and January (Figure 3). In 1948, 1949, 1951 and 1952, peak numbers were not observed until January. Only in two years (1950 and 1957) was a peak in December followed by a subsequent sharp decline.

In the Ontario-St. Lawrence region (Figure 4) less than 1,000 canvasbacks were recorded each year except in 1957 when some 10,500 birds were observed on November 5 and 25. A similar high of nearly 10,000 was reported in early November of 1958 by ground observation. Again the pattern was not regular. In 1952 the peak occurred in October, in 1948 in December, and in other years in November.

Graphs are not included for the Champlain or Hudson Valleys. In the Champlain valley the greatest number of canvasbacks observed at one time was 35, but ground reports in 1958 indicated larger flocks in November. In the Hudson valley numbers up to 1,000 were seen (December 1957) with peaks tending to come in late November and early December.

In the Long Island region (Figure 5) peak numbers occurred in mid-December in 1949, 1951 and 1952 and were followed by declines that

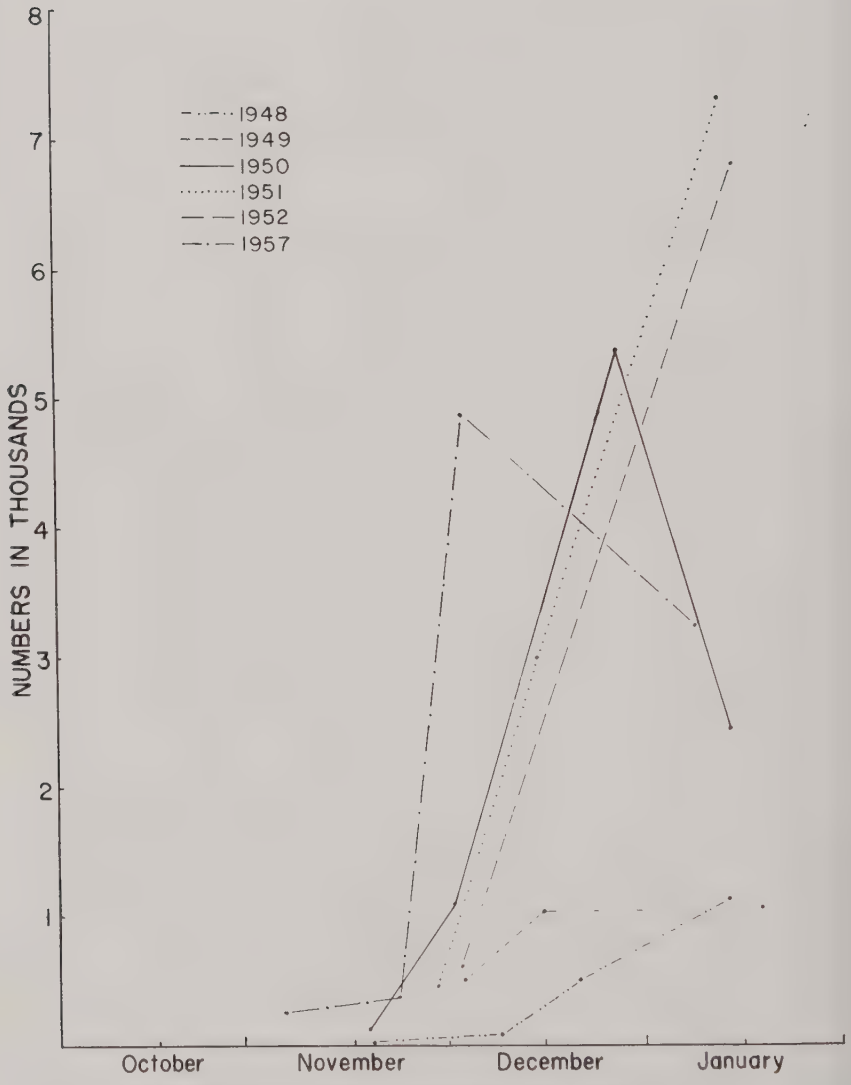

Figure 3. Fluctuations in canvasback abundance during the fall in the Lake Ontario region as indicated by aerial-census records for the years 1948 to 1952 and 1957.

extended into January. In 1948, 1950 and 1957 peak numbers did not occur until January.

In both the Ontario-St. Lawrence and Long Island regions exceptionally large flights of canvasbacks were observed in 1957. While not as large proportionately, the flights that year were above-average in the Lake Ontario and Central Lakes regions also. However, in the reports for January 1958 a decrease was reported for the Atlantic Flyway and

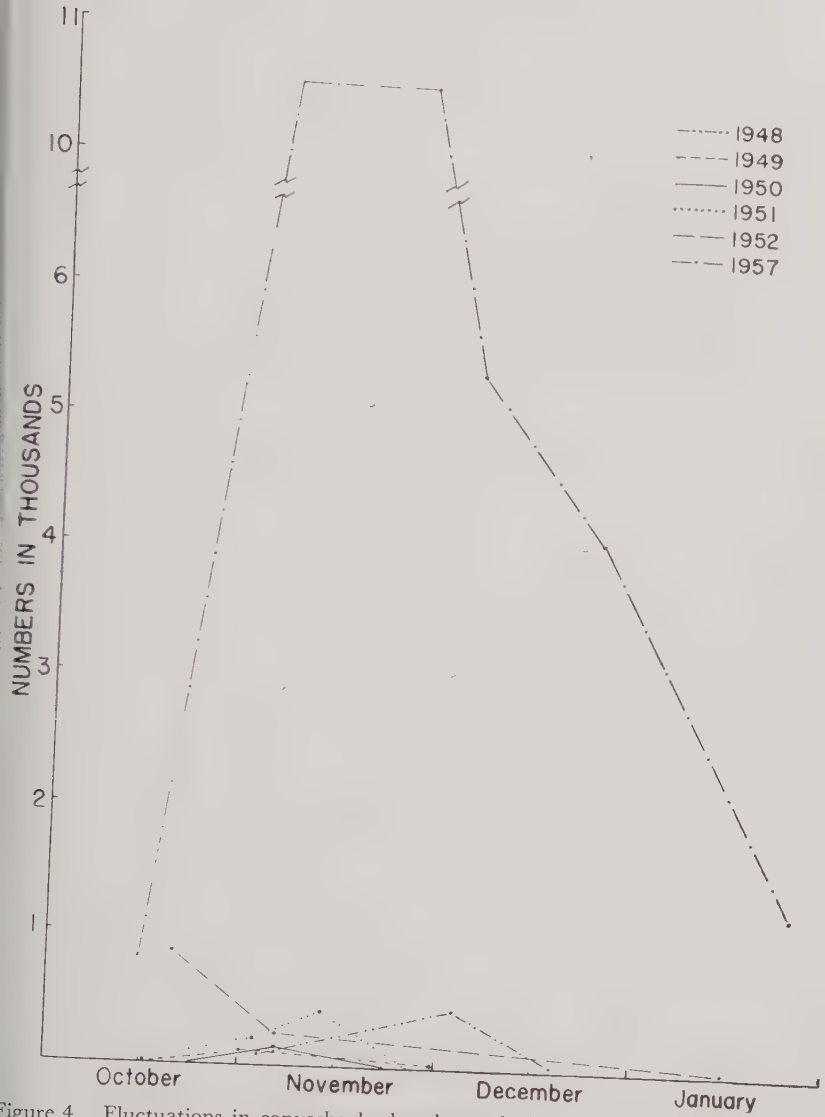

Figure 4. Fluctuations in canvasback abundance during the fall in the Ontario-St. Lawrence region as indicated by aerial-census records for the years 1948 to 1952 and 1957.

n increase for the Mississippi Flyway. A special upstate census during he last week of December in 1958 showed above-average numbers of anvasbacks in the Ontario-St. Lawrence and Central Lakes regions but ightly below-average numbers in the Lake Ontario region.

The main areas used by canvasbacks during the fall migration did ot vary appreciably from those used by the wintering flocks. To these ay be added the Croton Point section of the Hudson River and, in

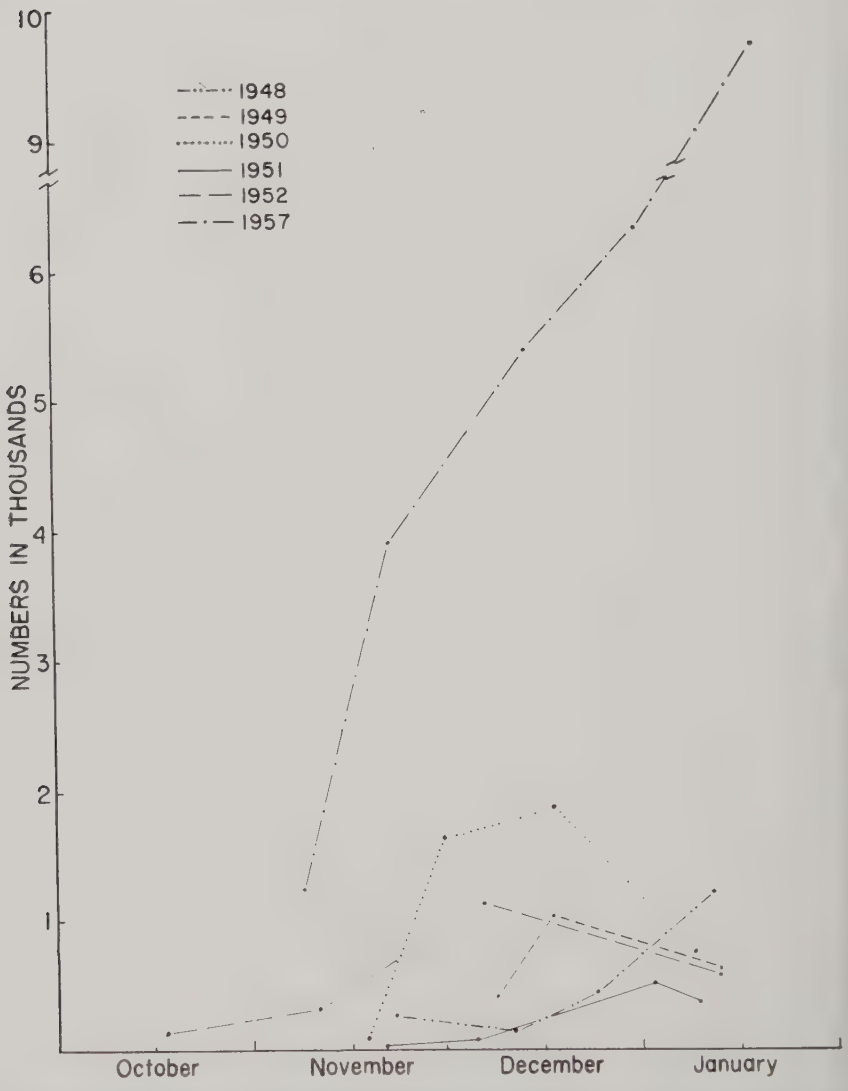

Figure 5. Fluctuations in canvasback abundance during the fall in the Long Island region as indicated by aerial-census records for the years 1948 to 1952 and 1957.

western New York, Conesus Lake which was commonly used during the fall period.

DISCUSSION

Throughout this series of aerial censuses John Schempp served as pilot, and from 1951 on Edward Maunton accompanied him as observer. The flight route was the same each year and covered all sections of the

State where canvasbacks winter except Lake Erie. Therefore, it would appear that a fairly consistent and reliable picture of the winter distribution of this species was obtained. With the data having been collected in a comparable manner, there would seem to be some significance in the fact that both the fall flights of 1957 and the midwinter inventory of January 1958 showed the greatest number of canvasbacks observed in New York in 11 years. Yet total figures for the Atlantic Flyway showed the least number in 10 years—a level some 55 per cent below the 11-year average. Three factors seem to offer partial explanations, but the writers feel that they have too little data at hand to reach a satisfactory interpretation. It is hoped, however, that this paper will stir others to review their data in search of an answer.

The first plausible factor may be that changing personnel or routes of aerial survey in other important canvasback wintering states have varied the representativeness of the censuses made there. Only the personnel closely associated with the local surveys can fully appraise this aspect. While it is commonly accepted that some ducks vary their degree of southward travel with the degree of severity of the fall and winter weather (Low, 1957), it does not seem logical that this would account for the great increase in abundance that was observed in New York. A change of from 1.3 per cent (1950) to 28.6 per cent (1958) in the proportion of the total for the Atlantic Flyway that was recorded in New York seems rather amazing. Also, the much greater annual variation in numbers for the Atlantic Flyway compared with that for the Mississippi Flyway leads one to question the reliability of the aerial censuses when the Atlantic Flyway carries the greater number of birds.

Another possible factor in the apparent decline of canvasback abundance in the Atlantic Flyway might be that the proportion of the population using the Mississippi Flyway has increased. But, while both the 1957 and 1958 winter records for the Mississippi Flyway were above-average and those for the Atlantic below, the drop in the Atlantic Flyway was too great to have been compensated for by the increase in the Mississippi Flyway, particularly in 1958. The possibility of some interchange of flyway populations does not seem too unreasonable, however, and it should be noted that canvasback numbers in 1958 were up 18.7 per cent in the Central Flyway and down 7.8 per cent in the Pacific Flyway. This may be important in evaluating the situation in the Atlantic Flyway.

Hunting statistics provide another line of inquiry. In Table 4 are given the numbers of canvasbacks reported killed in the four major flyways during the seasons of 1956–57 and 1957–58 as compiled by Crissey (1958). The total kill for the country as well as that for the Central Flyway differed little for the two years, but the kill in the Atlantic Flyway dropped substantially while the numbers taken in the Mississippi and Pacific Flyways rose.

Table 4. Comparison of Numbers of Canvasbacks Reported Killed in the Four Major Flyways in 1956–57 and 1957–58*

Flyway	1956–57	1957–58	Change (per cent)
Atlantic	98,604	72,888	−26.07
Mississippi	167,399	183,183	+ 9.43
Central	144,368	144,135	− 0.16
Pacific	56,935	69,786	+22.57
Total	467,316	469,992	+ 0.57

* Data from Crissey (1958).

Of more interest is the fact that the take decreased nearly 26,000 birds in the Atlantic Flyway but increased nearly 16,000 in the Mississippi Flyway. Since the canvasbacks that frequent the Atlantic Flyway are usually first subject to gunning in the upper Mississippi Flyway, some of the 16,000 may have been birds that would normally have reached the Atlantic Flyway before being shot. At least recoveries of canvasbacks banded in New York during the winter suggest that a more-than-normal proportion of this stock was harvested in the upper Mississippi Flyway in 1957–58. In that year 38.8 per cent of the banded stock was taken north and west of New York; in 1955–56 the proportion was 29.4 per cent and in 1956–57 it was 31.8 per cent. Thus it appears that this might have been a contributory factor in the apparent canvasback decline in the Atlantic Flyway.

Probably the bulk of the canvasbacks that winter in the Atlantic Flyway are produced in Manitoba, North Dakota and Saskatchewan, but it is known that birds produced in Alberta and Mackenzie, and probably other parts of the canvasback breeding range also contribute to this population. However, these same regions also contribute birds to the other flyways. Therefore, it seems most surprising that the Atlantic Flyway population should suffer a decline that was apparently not reflected in the other flyways, especially the Mississippi Flyway. The records provided by Addy (1958) and Crissey (1958) suggest another approach (Table 5).

In presenting these data in this form it is recognized that the figures for hunter kill and winter population are estimates, each developed on a different basis, and hence only indicative of trend relationships. They suggest, however, that canvasbacks were subject to a rather high harvest in relation to their total numbers—perhaps on the order of 50 per cent. For canvasbacks banded in the Prairie Provinces, Low (1957) reported direct recoveries of 22.4 per cent for 1954 and 28.4 per cent for 1955. Since not all banded ducks shot are reported (the proportion has been variously estimated at from a third to a half) Low's report strongly suggests that the estimates may be quite representative.

TABLE 5. COMPARISON OF HUNTER KILL RECORDS AND WINTER POPULATION ESTIMATES OF CANVASBACKS FOR THE ATLANTIC AND MISSISSIPPI FLYWAYS FOR 1956–57 AND 1957–58

Item	Atlantic	Mississippi	Total
	1956–57		
Hunter kill*	98,604	167,399	266,003
Winter population§	175,000	110,000	285,000
Total†	273,604	277,399	551,003
Percentage harvested	36	60	48
	1957–58		
Hunter kill*	72,888	183,183	256,071
Winter population§	100,000	100,000	200,000
Total†	172,888	283,183	456,071
Percentage harvested	42	65	56

* Data from Crissey (1958).
§ Data from Addy (1958).
† Represents approximate preseason population.

From these figures the harvest in the Mississippi Flyway was obviously more than the estimated preseason population could long tolerate. Therefore, it must also have included stock that would normally have been in other flyways during winter-inventory time. Recoveries from birds banded during the winter in New York seem to verify this assumption. Hence, it seems apparent that the canvasback populations of the Mississippi and Atlantic Flyways cannot be considered separately.

This was recognized when the bag limit for canvasbacks in both flyways was reduced to two for the 1958–59 season. Shortening the season in the Atlantic Flyway but not in the Mississippi Flyway probably did little to protect the canvasback. Low (1957) showed that, for canvasbacks banded in Manitoba, a greater proportion of the accumulated direct returns came from the Mississippi Flyway (28.8 per cent) than from the Atlantic Flyway (19.2 per cent). This again is in keeping with the hunter kill records which show that the harvest in the Mississippi Flyway tended to comprise 60 to 70 per cent of the canvasbacks taken in both flyways.

In a study of the distribution of the canvasback population throughout the continent, Stewart *et al.* (1958) presented breeding-population indices to "show that the number of breeding canvasbacks remained fairly stable during the years 1953–56". January aerial-inventory figures, as compiled by the U. S. Fish and Wildlife Service, show a somewhat different picture (Table 6). That these two methods of measuring

Table 6. Comparison of Winter Population Estimates and Breeding-ground Indices of Canvasbacks for the North American Continent from 1952 to 1956

Item	1952	1953	1954	1955	1956	Average
Winter population*.....	384,000	563,000	669,000	510,000	415,000	508,000
Breeding-ground index§..	..	368,550	313,150	352,600	389,700	363,100

* Data from U. S. Fish and Wildlife Service.
§ Data from Stewart *et al.* (1958).

populations are still in their embryo stages is amply shown by the fact that the highest inventory figure and the lowest breeding-ground index were both obtained in 1954. Similarly, the next-to-lowest inventory figure and the highest breeding-population index were those for 1956. In both sets of data the regional components were far more variable than the annual totals. Midwinter inventory records for New York (Table 1) show no correlation with the continental figures, having fallen below average in 1953 which was the only year that both sets of continental figures were above average. It appears that no definite conclusions can be drawn regarding population trends from these data.

The work of Stewart *et al.* (1958) brings out the important stake that New York, the Atlantic Flyway and especially the Chesapeake Bay region have in the welfare of the canvasback. The average midwinter inventory figures for the continental population from 1952 to 1956 indicated the following proportions for various parts of the East: Mid-Atlantic States, 57 per cent; southeastern States, 5 per cent; upstate New York, 5 per cent. Thus the Atlantic Flyway includes the wintering grounds for roughly two thirds of the continental canvasback population which at best numbers less than a million birds.

In New York canvasbacks make up only a small part of the wintering waterfowl population, averaging less than 10 per cent of the total. Moreover, when one considers that during October and most of November canvasbacks are scarce or absent while thousands of dabbling ducks are passing through the State, it seems probable that this very popular species provides less than 1 per cent of the potential duck targets during the open season.

Moreover, while it is difficult from the aerial census records for New York to see at this writing (1959) that the canvasback is in trouble, this conclusion must be inferred from the reports of drought on the breeding grounds and the low numbers reported during the winter inventory for the Atlantic Flyway as a whole. Therefore, until the status of the canvasback can be demonstrated to be more favorable, relaxation of hunting regulations for this species will not be justified.

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REACTIONS OF AQUARIUM CARP TO FOOD AND FLAVORS[1]

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ABSTRACT

The reactions of carp to 115 flavors and many types of food were observed at the State Fish Laboratory at Livingston Manor. The test fish detected all the oils and a number of water-soluble flavors, but not alcohol and salt. Several water-soluble compounds stimulated feeding activity in blind fish although the fish were unfamiliar with them.

Tests indicated that adult carp will accept almost all foods without regard to color but will not eat those they cannot crush with their pharyngeal teeth. Ability of blind carp to catch some fast-moving animals was demonstrated.

Observations of feeding activities revealed a complicated but stereotyped set of actions, with certain senses dominant over others at times. Sympathetic activity among the senses was also revealed.

As part of efforts to develop an attractive poison bait for carp control, a large number of extracts were tested for acceptance. The results provide a good picture of the vagaries of a study of this kind.

It has long been recognized that fish are, like most animals, capable of taste and odor discrimination. As defined by Hasler (1957) odor and taste perception are interpreted here as those chemically induced sensations which are relayed to the central nervous system from the olfactory sacs and the gustatory nerve endings in the mouth or on the barbels and other body surfaces. Also accepted here is his view that a smellable substance must pass into solution on the mucous film to be perceived by a terrestrial vertebrate; that smell in all animals is aquatic in the final sense. This is undoubtedly true of taste perception also.

The histology of the taste organs and olfactory sacs has been described in detail for several species of fish, although the location of taste receptors has not been adequately determined. Also, the exact functions of the various taste and odor receptors remain unknown. Evans (1952) showed correlation between the well-developed vagal and facial lobes of the carp and its feeding habits. The vagal lobes receive branches of the 10th cranial nerve from the taste buds in the pharynx and posterior portion of the oral cavity, while the facial lobe receives gustatory fibers of the 7th cranial nerve from the barbels, lips, snout, and body surface. Broad ability to perceive taste is anatomically demonstrated for the carp, and is also borne out by observations in this laboratory.

The entire field of flavor perception suffers from a lack of means of measuring quality and quantity of flavors and the responses of animals to them. Different species show dissimilar reactions to the same flavors. Individuals within species may respond differently as the result of in-

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

dividual experience (very important in the case of adult humans) or varied ability to perceive certain flavors.

Response to water-borne or air-borne flavors has been largely neglected by biologists. However, some analysis of taste perception, i.e., to the extent that the electrical response of individual nerve cells to various flavor stimuli has been measured, has been carried out in a few mammals. Such studies are anything but complete for any species, but they do indicate the extent of the problem.

It has been found that individual receptors are capable of perceiving a variety of flavor qualities, but the extent of this ability has not been determined. Actual physiology of the receptors, concentration of flavor substances and their manner of presentation (size, shape, number, mixture with other flavors, temperature, duration of application, etc.) and other factors are involved.

Testing the effect of flavors on humans is a complicated procedure demanding both trained and untrained (but intelligent) panels of tasters. Results are analyzed statistically, but based on opinion. That this is not a foolproof method was demonstrated during World War II when soldiers spurned food that had been preferred by "experts" (Lockhart, 1958).

Flavor quality itself has not yet been calibrated as have energy frequencies such as visual wave lengths of light. The standard qualities of sweetness, sourness, saltiness and bitterness have been inadequate for explaining human and other animal responses to flavors (Pfaffman, 1958). Rather, it appears that responses are related to an infinite number of combinations which in turn have little relationship to these so-called basic tastes.

Flavor, interpreted as taste or odor, is capable of evoking responses in humans that are more rapid than those from the stimuli of light and sound. If people ignore extremes of bright light and loud sound, it is obvious that they are not attracted to or revolted by certain colors and sounds to the extent that they are by certain tastes and odors.

Although comparison of carp and humans may often be questionable, this last statement may apply to fish also. Varying light intensities appear to evoke little detectable response in carp, but flavors do. None of the 115 flavors tested as water-borne extracts evoked a repelling reaction that could be detected, but certain foods impregnated with some of them were spit out. All extracts, with the possible exception of pure ethyl alcohol and salt, were detected (visual test) by carp. To most flavors, carp were indifferent after tasting. Some evoked vigorous feeding responses.

The thousands of tests involving flavors and foods have permitted observations of the methods by which carp locate food in aquaria. These observations have, in turn, led to the formulation of ideas concerning

the relative importance of the senses and their relationships to each other and to the activity of the fish. The work is necessarily incomplete, and many phases may warrant further detailed study.

GENERAL METHODS

Fish used as subjects were all carp from two sources. Those from one source were stunted, 1 to 4 pounds in weight, and good feeders. The others were fat and weighed 5 to 10 pounds; most of these could not be induced to feed even after being starved for several months.

The flavor tests and other studies were carried out in 350 to 550-gallon temperature-controlled aquarium tanks (Loeb, 1959) that permitted observation through plate glass from the side (observation from above panics carp and is deceptive to the observer due to refraction of light). Normal fish were used until it became apparent that visual stimuli (visual detection of food or people) were dominant over senses of taste and smell. Blind fish were generally used thereafter.

Initial tests of different flavors were made only after an interval of at least 24 hours following a previous test.

All fish were in apparent good health. The reader may assume that all were active feeders, unless otherwise stated.

RESPONSE OF CARP TO VARIOUS FLAVORS

The 115 substances tested included a number of the table variety and a large group in the essential oil class. Blind carp weighing from 1 to 3 pounds were used as test fish. At least six fish were used in each test. All flavors were retested; an interval of 24 hours was allowed between tests. None of the fish had previously tasted any of the flavors. The reactions observed are summarized in Tables 1 and 2.

For each water-soluble flavor (Table 1) one eye dropper or teaspoonful was dissolved in a pint of water. This was poured into the inlet stream over the fish and results were noted. Each oil-soluble flavor (Table 2) was tested in two emulsified forms: first, oils were emulsified in a blender; for repeat tests, in a mixture of polyoxyethylene sorbitan monooleate.

Strangely enough, no oil-soluble flavors produced a positive feeding reaction, although all were detected by the fish as evidenced by brief snapping of the jaws. The feeding reaction is defined as the searching portion of the chain of events starting with appetitive behavior (Baerends, 1957) and ending with nonfeeding behavior after eating. The feeding reaction in this case may be described as a horizontal search for food on the tank floor or more rarely on convenient vertical surfaces. It was often preceded by a slow, descending spiral movement from the stratum of flavor-bearing water to the tank floor.

The tests were made in an effort to find exotic substances which would trigger the feeding release mechanism. Several were demon-

strated to be positive triggering agents, but their chemical structure is imperfectly known and their physiological effort even less so.

Feeding behavior of carp, as evidenced by fish held in aquaria, consists of stereotyped reactions. These reactions are triggered by various stimuli which release activities that lead to further stimuli and finally eating. A portion of this routine may be classified as appetitive behavior or a search for the stimuli which will release feeding or other activities. Appetitive behavior is sometimes thought to involve reasoning or learning, but in the case of carp at least it does not appear to include the former.

The sequence of feeding activity can be empirically described in somewhat general terms and without the benefit of much physiological fact. At best, the description is inadequate and may not be a true measure of what actually happens.

Normal fish are often moving; blind fish, always. Movement appears to increase in hungry fish. This may be appetitive feeding behavior, or a search for stimuli that will release an active search for food. That this is not always so is evidenced by the continual movement of nonfeeding blind fish. "Aimless" moving in carp probably serves many purposes, one of which is the appetitive search for food stimuli. Regardless of the number of basic instincts to be served, a carp is capable of only limited variation.

The total feeding sequence appears to be as follows: (1) Frequent appetitive movement in normal fish; continuous in blind fish. (2) Triggering by external stimuli such as sight of a person or food, vibrations, touch of food, or a taste or odor. (3) Further appetitive behavior as a result of triggering (this was the criterion of a "natural" flavor) that releases an active search for food. This is direct if the triggering stimuli are visual, but indirect for taste, odor or touch. Carp will attempt to increase the taste or odor stimuli by appetitive snapping. One stimulus may follow another as with vision-touch-taste, or odor-touch-taste. (4) Actual grasping of food and eating. The latter may be interrupted by the addition of more food which starts the sequence again at Stage 2. Grasped food must first be spit out. (5) Eating until satiation occurs. Normal fish will then rest and refuse food in most cases, although a few individuals can be continually stimulated by adding new food.

Addition of a "natural" flavor often causes blind fish to find and eat foods such as snails which are not otherwise detected (unless by chance touch) in the aquaria.

The majority of compounds were ignored after initial detection; ethyl alcohol and salt were not detected, possibly because concentrations were low. Table 1 lists all of the triggering agents found, which include imitation maple flavor and two of its components, tobacco, saliva, brown sugar, white sugar, molasses, saccharin, instant coffee, beef bouillion,

Table 1. Reactions of Carp to Water-soluble Extracts *

POSITIVE FEEDING REACTION	
Beef bouillion	
Coffee, instant	
Earthworm extract, filtered	
Foenugreek, solid (component of maple flavor)	
Liver extract, filtered	
Lovage, solid (component of maple flavor)	
Maple flavor, imitation, extra	
Molasses	
Saccharin	
Saliva	
Sugar, brown	
granulated	
Tobacco juice, filtered (nonaromatic mix)	
filtered (aromatic plug)	
Tobacco juice & saliva (aromatic plug)	
Tobacco juice & particles (aromatic plug)	
VAGUE FEEDING REACTION	
Maple syrup, 15 per cent	
INDIFFERENCE AFTER TASTING	
Aromatic mixture, B-48, solubilized §	
C-48, solubilized §	
D-48, solubilized §	
L-48, solubilized §	
Butterscotch flavor, imitation	
Monosodium glutamate	
Raspberry gelatin	
Vanilla extract	
NO REACTION DETECTED	
Ethyl alcohol, 200 proof	
Salt, table	

* In all cases test fish were blind and unfamiliar with substance being tested.
§ Fruity flavors solubilized with polyoxethylene sorbitan monooleate and manufactured by Magnus, Mabee & Reynard, Inc., New York.

liver extract, and earthworm extract. The physiology of taste and odor involved here is unknown. Blind fish without ability to perceive odors also reacted to all of these substances. Several have a pleasant taste to humans, but extracts of lovage and foenugreek seeds can only be considered as vile tasting. From these data, it may be seen that some of the old standbys, such as spitting on the bait, may have some basis in fact.

Table 2 illustrates the general indifference of carp to a number of substances which have often been thought to have some attractive qualities. Anise is a prime example. Carp ate all these flavors when they were incorporated in fish pellets in small quantities, but whether this was because of or in spite of the flavor ingredient is not known. Fish pellets were definitely a preferred food after a few feedings, although some individuals refused them at first. Dough baits (flour and cornmeal in equal amounts) were readily accepted for several days, after which all fish refused them. When incorporated into dough baits, some flavors, such as oils of clove, thyme, and citronella, were reluctantly eaten after much spitting out.

In dough baits the relative acceptability of most flavors was difficult to measure. It appears that acceptability is also affected by other qualities than flavor. Preferred foods were not made repulsive by any of the flavors tested.

ACCEPTANCE OF VARIOUS FOODS

A number of foods were fed to normal carp during many hundreds of

TABLE 2. REACTIONS OF CARP TO INSOLUBLE EXTRACTS *

POSITIVE FEEDING REACTION

Olive oil with sardine particles
Soybean oil with sardine particles

INDIFFERENCE AFTER TASTING

Allspice oil (oil pimento), N.F.
Almond oil
Anethole from pine oil
Anise oil
Aromatic mixture B-48 §
C-48 §
D-48 §
L-48 §
Balsam Peru oil, ext. genuine balsam
Bay oil
Bergamont oil
Bitter almond oil (free from Prussic acid)
Bois de rose oil, Brazilian
Cajeput oil, rectified
Calamus oil
Camphor oil, water white
Canada snake root oil
Cananga oil
Caraway oil, N.F.
Castor oil
Cedarwood oil, American
Celery seed oil
Chenopodium oil (American wormseed oil), N.F.
Cinnamon oil
Citronella oil
Cloves oil
Cocoanut oil
Cod-liver oil (liver oils of cod percomorph and other fishes)
Cognac oil, Rhine green
Copaiba oil, U.S.P., 8th revision
Coriander oil, U.S.P.
Corn oil
Cottonseed oil
Cubeb oil, U.S.P., 9th revision
Cumin seed oil
Dill seed oil
Eucalyptus oil, N.F.
Fennel oil, U.S.P.
Fleabane oil, American
Geranium oil

INDIFFERENCE AFTER TASTING

Grapefruit oil, American expressed
Guaiac wood oil
Hemlock oil, American
Laurel oil, expressed
Lavender oil
Lemon oil
Maple flavor, imitation (oil soluble)
Olive oil
Olive oil, filtered from sardine can
Origanum certic oil
Palm oil
Patchouly oil
Peanut oil
Pennyroyal oil
Peppermint oil
Petitgrain oil, South American
Pine oil
Pine needle oil, Siberian type
Rapeseed oil
Rectified tar oil, N.F.
Rhodium oil, select
Rose oil, artificial
Rosemary oil, N.F.
Rue oil
Sage Dalmatian oil
Sassafrass oil, N.F. (natural)
Savin oil, U.S.P., 8th imported
Sesame oil, U.S.P.
Soybean oil
Spearmint oil, N.F.
Sperm oil
Spike oil, dark
Spruce oil, American
Sweet birch oil, U.S.P. (Betula oil, U.S.P.)
Sweet marjoram oil
Tangerine oil
Tansy oil, American
Thuja (*occidentalis*) oil, U.S.P.
Thyme oil
Ti-tree oil, Australian
Verbena oil (a compound)
Vetivert oil, Reunion
Wine oil (so-called heavy)
Wintergreen leaf oil, U.S.P. (northern *Gaultheria procumbens*)
Wormwood oil, American
Ylang ylang oil (artificial)

* In all cases test fish were blind and unfamiliar with substance being tested.
§ Fruity oils manufactured by Magnus, Mabee & Reynard, Inc., New York.

tests. These included whole-kernel corn, cracked corn, wheat, oats, buckwheat, soy beans, navy beans, all available livestock feeds, and all available forms of macaroni and noodles. All these foods were presented in original form or coated with food dyes, india ink or shellac. All preferred foods were eaten regardless of color, covering or mixture. Some foods such as beans and split peas usually could not be crushed and, in such cases, were rejected regardless of treatment.

All foods ingested are crushed between the pharyngeal teeth and the basioccipital bone (a skull bone) which is covered with a cartilagenous structure known as the pharyngeal pad. The opening to the esophagus is too small for large particles. The pharyngeal teeth, components of a modified gill arch, are capable of grasping, sorting, rejecting and crushing. Taste buds are present in this area. The efficiency of this grinding mill is evidenced by the ability of the fish to spit out tiny lead shot embedded in corn kernels while eating the corn. The importance of the pharyngeal area with respect to food acceptance is emphasized by the highly developed vagus lobes at the posterior end of the brain.

Carp often fill the mouth with food which is slowly crushed by the teeth. Large meals cannot be eaten because a stomach is lacking. Although the forepart of the intestine is large and somewhat expansive, these fish probably eat often and lightly under natural conditions.

Live, active foods were attractive. A number of aquatic insects were eaten readily by both blind and normal fish. Earthworms were taken at once. Salamanders were quickly seized and swallowed. Blind fish were able to capture crayfish, after chance touching, by a quick movement of the head combined with suction. Normal fish often chased crayfish for a short distance (a foot) but quickly desisted if flight continued.

It appears that carp might be caught most readily in clear water by bait which is occasionally moved in small hops to attract attention. In muddy water, the bait should remain in place, but an attractant such as maple flavor might be added to it and the immediate area.

USE OF SENSES IN FINDING FOOD

The feeding reaction is initiated by a stimulus received through any of the senses. Normal fish feed by sight whenever possible; but blind fish must depend upon other senses. Fish which have neither a sense of sight nor of smell are still able to locate food efficiently by taste, sound, or touch. In certain instances one sense appears to be the guiding force, although another sense may become dominant.

In clear water normal fish are the most efficient at finding food and eat by sight whenever possible. Visual stimuli lead them directly to food in most instances, but coordination is provided by the sense of touch.

Normal carp in an aquarium immediately detect a person (undoubtedly due to conditioning by being fed) and crowd violently toward him. Any small object thrown into the tank is immediately seized (fish learn, after a period of time, not to seize certain foods such as dough baits), and final acceptance or rejection takes place in the mouth. Inedible objects such as tar, putty and pebbles are often carried for several minutes in the mouth. The fish soon show less attraction to inedible objects, but may be restimulated to pick them up by the addition of a preferred flavor or by the sight of additional food, feeding fish or a person.

Flavors sometimes produce a snapping reaction in normal carp, but more often the fish react initially only to visual stimuli. When they do react, the flavor stimulus may be received by the olfactory nerves or taste buds located in the mouth and over much of the body.

Normal carp can locate surface food by sight but usually do not attempt to eat. Occasionally surface food is gulped in an aimless, uncoordinated manner, but most of such food is left uneaten. Falling food is readily seized through sight although coordination is so poor that much is missed. Food which lays on the bottom is located by a combination of vision and touch, and the latter may be dominant. On this two-dimensional plane efficiency and coordination are high. Food which rests on surfaces only an inch above the tank floor is often ignored, even when in sight. Normal adult carp, or those in clear water, are primarily bottom feeders although some food is undoubtedly taken in mid-water or at the surface.

Normal fish (regardless of size) school by sight in aquaria and this may have a relationship to feeding frequency. In at least one tank, a particular, easily stimulated fish was the first to take food, followed always by a second particular fish, and finally by the entire school. These fish were new and unaccustomed to the tank. Nevertheless, the quick stimulation of one fish resulted in more food consumption in this tank than in other tanks of new fish. Among acclimated fish activity of this type was never observed.

Carp fry may be almost completely dependent upon vision for feeding. Fry appear to feed on zooplankton which they obtain mostly during the day, rarely at night (Alikunhi, 1958). This may be a reason for the lack of young carp in many turbid waters where adults are abundant.

Adult fish seldom eat small particles unless the particles are massed. Normal fish will investigate a cloud of colloidal liver, snap at the flavor, and attempt to eat the cloud. As the cloud disperses, the fish are ultimately bathed in a sea of particles which they ignore. Larger introduced particles are seized. It is interesting to note that carp will flee before slowly spreading "black" clouds of malachite green. Some may jump from the tank. Upon envelopment by the cloud, violent activitity ceases. ("Ink" emitted by squids may produce panic rather than a blinding effect.)

In general, it may be said that normal carp feed by sight, but they locate their food by sight and touch. Stimulation to search for food may be provided by any factor which affects any sense.

Blind carp (and possibly normal carp in turbid water) are able to detect as little as one part of liver extract in 180 million parts of water, or a single fish pellet in a tank. Blind fish without olfactory perception are equally sensitive. Thus it becomes obvious that the sense of taste is acute.

The movements of blind carp are continuous, but relatively slow and deliberate as compared with those of normal fish. High speeds are usually avoided and as a result walls are gently contacted. The fish do bounce off of smooth surfaces if other obstructions are lacking and will repeat this maneuver again and again. Smooth surfaces are used for unconventional schooling, the fish continually streaming back and forth along them, often in contact with each other. Food is obtained during high-speed swirling in the center of the tank, but feeding actions are slow and deliberate in corners and at the sides. Logs and branches are actively overturned in search for food.

If a preferred flavor, such as liver extract, is detected with the rear portion of the body, a fish backs up until a tail-down vertical position is reached, after which it often falls over backwards. Snapping is continuous during this maneuver. The fish then circles rapidly to the floor of the tank and searches for food; at this time the sense of touch is dominant. Searching ceases after a few minutes if the fish is not rewarded with food. Addition of more extract forces a repetition of this performance, but continued introduction is ignored as the water becomes "saturated" and the taste and odor receptors fatigued. A new flavor such as maple extract will elicit a response at this point.

Blind fish are not able to follow a "trail" of flavor. Actually, trails do not exist as such except in single-direction currents. Rather, a fish is quickly immersed in a solution of the flavor substance and is stimulated to feed in that vicinity. Most of the fish gather where the flavor is strongest and arrive there by chance. The stronger the flavor, the more violent and efficient the feeding reactions. Apparently reason is not used; the fish remains where the stimulus is most acceptable.

A single trout pellet will cause all blind fish in a tank to search for food. Any fish that crosses the trail of a falling pellet reacts as it would to an extract. Almost immediately the other fish are stimulated by body movements, tooth noises or spreading flavor, and all begin to feed. Attempts, almost always unsuccessful, are made to seize food in mid-water. On the tank floor, the search is quick and efficient, and food is rapidly located by any chance touch. A falling particle will elicit snapping if it touches the body of a carp, but feeding will take place only if it has a flavor component.

Inedible objects are usually avoided, although some may be picked up. If such objects are abundant, feeding is retarded. Under natural conditions location of food is probably slowed by many obstructions.

Liver extract and all other flavors are detected by carp in conjunction with snapping, whether the fish are normal, blind, or without olfactory perception or barbels. Snapping is an apparent attempt by the fish to increase the amount of stimulus caused by the extract. Perception of odor in mammals occurs only when a gas is actually moving over the

olfactory nerves. Increased air movement resulting from sniffing increases the stimulus. Odor cannot be detected, even if the originating substance fills the nasal passages, unless the air is moving.

Ordinary movement by fish would appear to enable stimulation of the olfactory and gustatory nerves (pure water causes momentory snapping if squirted directly into the nares), and snapping probably increases perception. In this way a fish ascertains the nature (i.e., pleasant or unpleasant) of a substance very quickly. The continuous movement of blind fish would appear to be efficient in maintaining contact with the environment.

Perception of sound appears to play only a small part in the feeding of normal fish, but it might be important in natural waters at night. Blind fish learn to associate vibration with food and will search if the tank is touched. In fact, blind fish finally learn to search for food regardless of stimulus. Any flavor or vibration will result in a feeding reaction; this is the same as saying that any non-violent change in the environment will cause feeding, if the change is perceived. For example, perception of a person by normal fish will produce feeding reactions in blind fish in the same tank. Blind fish are apparently capable of detecting changes in the movements of the other fish.

Under any condition sight is probably the most efficient locating mechanism, although final choice takes place in the mouth. Various stimuli actually lead the fish involuntarily to food. Other powerful stimuli (internal) may prevent fish from finding food as in the case of non-feeders.

The feeding reaction caused by the presence of a person might appear to be reasoning, but is probably learning. Loss of sight reduces the animal to apparent stupidity until it learns to link a person with vibration.

SYMPATHETIC ACTIVITY AMONG SENSES

It has been demonstrated that olfactory response is increased in rats by any stimulus which may excite the animal (Beidler, 1958). In other words, the ability to perceive odors is enhanced by stimuli received by other senses and transmitted to the autonomic nervous system. Data recorded during limited temperature experiments indicate that carp may be subject to such a relationship between visual and taste perception.

Normal adult fish fed actively at temperatures of 65° to 90° F. In the higher portion of this range, movements were precise, delicate, rapid and efficient. At 90° to 95° F. feeding was less active. Seizing of food at temperatures of 95° to 102° F. occurred, but little attempt was made to actually eat. Discomfort was evident.

Feeding was less active at temperatures below 65° F. A few normal carp fed sluggishly at 45° F. even if held at that temperature for months. Many fish ceased feeding at 45° F. and some fed for only a few days

(8-inch carp netted from natural water at 32° F. have been found filled with plankton).

Feeding carp reacted to a preferred flavor such as liver extract at any temperature at which they still fed. Non-feeding carp did not react regardless of temperature. In reverse it might be stated that any fish which reacted to an extract would feed.

Blind fish followed a pattern which was generally similar to that of normal fish. However, they ceased both feeding and reacting to extracts at approximately 50° to 55° F.

It thus appears that visual stimulation lowers the temperature threshhold at which odors or tastes can be detected. If true, this is a case of sympathetic activity between senses. It is also an indication that perception by various senses does not become more highly developed, as is commonly thought, when another sense is lost. Rather, the reverse is true, i.e., all remaining senses lose some perceptive capacity when one sense is lost.

Incapacitated animals probably learn to use their remaining senses to better advantage than they would have without the destruction of one stimulus-receiving route. This is not the same as an increased development of the remaining senses. In fact this limited evidence suggests that activity resulting from learning by an abnormal animal will never equal that of the same individual in a normal state. This analysis must remain theoretical without further study. However, it is suspected that the same phenomena might occur at extremely high temperatures also.

Sympathetic activity among senses has been amply illustrated by the success of teaching methods employing as many areas of sense perception as possible. Such coordination of senses is probably of great aid to fish in their aquatic environment. Any environmental factor which impedes the use of one sense is bound to reduce the effectiveness of the others, too, and both directly and indirectly to affect the fish's well-being.

Carp would appear to be at a disadvantage in turbid waters at low temperatures.

DISCUSSION

The observations reported here are a small addition to the study of fish behavior. An infinite variety of subjects are available for further original work. Any investigation should reveal new facts which may be useful in fish management. The results of the present work should be helpful in designing a poison bait for carp control. The use of a "natural" attractant, such as imitation maple flavor, which is foreign to the environment may also improve fishing. Other species are probably affected by these or other flavors. Carp are obviously forced to react to certain flavors, but the physiological relationships involved are little understood. There is similar lack of knowledge concerning the chemistry of most of the

flavors tested. Why only alcohol and salt should not be detected remains a mystery. Similarly, the reasons for the attractive qualities of certain compounds listed in Table 1 are unknown.

The feeding activities of carp are stereotyped, but they are also complex. The activities noted in aquarium tanks must still be correlated with activity in natural habitats.

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LETHAL OXYGEN CONCENTRATIONS FOR THE NORTHERN COMMON SHINER

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ABSTRACT

Mean lethal oxygen levels for the northern common shiner (*Notropis cornutus frontalis*) were determined at several temperatures from 55° to 80° F. The mean values ranged from 0.54 to 1.23 p.p.m. and gave a straight-line curve when plotted on semi-logarithmic paper.

The test procedure involved placing each fish in a closed container and obtaining a gradual reduction of the oxygen content of the ambient water by the respiratory activities of the confined fish. Residual oxygen concentrations were determined for the water in each container when the test fish was completely over on its side with barely perceptible gill movements.

On some occasions fish kills in which all or nearly all the fish involved were minnows have resulted from depletion of dissolved oxygen due to organic wastes discharged into streams. In such cases, data on lethal oxygen levels for minnows are needed in connection with investigations of the sources of pollution. Very little information for any of the species common to New York streams could be found in the literature. Therefore, tests were made to determine these values for the northern common shiner (*Notropis cornutus frontalis*). This species was chosen because it seemed to be moderately sensitive to reductions in the amount of dissolved oxygen.

The study was begun in 1952 and completed in 1956. All fish used were seined from a short section of Flint Creek just north of Gorham in Ontario County. This section of the stream was free from pollution except for a small amount of household wastes. Black spot (*Neascus* sp.) was present on some of the fish, but no fish noticeably parasitized was used in any of the tests. Nearly all fish were in age group I, although a few of the smallest were young of the year and a few of the largest were possibly in age group II.

The tests were run at five temperatures: 55°, 65°, 70°, 75°, and 80° F. All the fish used in tests at 80° F. and part of those in tests at 75° F. were seined during mid-April or early May when stream temperatures were rising. The remainder used in tests at 75° F. and all of those used in tests at 70°, 65° and 55° F. were seined in late October, November, or in December (a few one year), when stream temperatures were falling. Those used for the 55° F. temperature were seined at a stream temperature only a few degrees lower than the test temperature and thus required a minimum adjustment during the acclimatizing period.

The minimum holding time for acclimatizing the fish to the assay water was 8 days; the maximum, about 30 days. Most fish were acclimatized to the test temperature for more than 7 days, the minimum being 4 days and the maximum, 26 days.

The fish were fed chiefly on bread crumbs, with chopped night crawlers or chopped lean beef used to provide some meat. No food was given for about 48 hours before the start of any test.

Mortality during the holding time prior to testing never exceeded 10 per cent of the stock and was usually less than 5 per cent. After testing at any temperature had begun, further mortality in the stock was very slight. No mortality occurred in the stock used for the 55° F. temperature, and only three fish died in two different stocks used at 80° F. The greatest mortality occurred in those used for the tests at 70° and 75° F.

EXPERIMENTAL PROCEDURE

The fish were held in glass aquaria of about 17 gallons capacity. The test jars were also placed in these aquaria during the tests. Constant temperature was maintained within ±½° F. with a Fenwal bimetallic thermoregulator in one aquarium and a Cenco bimetallic thermoregulator in another aquarium. The heating elements were 75- to 100-watt, sand-filled, Pyrex glass acquarium heaters. No temperature recorders were available, but close observation of the temperature was kept. The water in the aquaria was kept aerated at all times with a Marvel Model C Aerator. The dissolved oxygen concentration in the aquaria ran slightly above 7 p.p.m. according to several determinations made during the test period.

The experimental water was Rochester (N. Y.) tap water from Hemlock Lake, the same as that used by Burdick *et al.* (1954) for their brook trout studies. Some variation in composition existed for a portion of the tests at 65° F. and for all those at 55° F. These were made in 1956 at the Scottsville headquarters of the Pollution Unit. The water source was the same, but the service to the area was recent and new transite piping caused an increase in pH to 8.92 with a decrease in total alkalinity to about 36 p.p.m. of which 5.0 p.p.m. was phenolphthalein alkalinity. This change did not appear to have any effect on the results.

Glass jars, ranging in capacity from about 1 pint to 2 quarts according to size of fish and test temperature, were used as test containers. The jars were sealed with rubber stoppers fitted with 3-millimeter (inside diameter) glass tubing. The tubing was inserted in the stopper so as to be flush with the bottom surface; the outside portion extended 2 to 3 inches with a short length of natural rubber tubing attached so the jar could be closed off with a clamp.

Water for filling the test jars was drawn 1 to 2 days before use and was brought to the test temperature with a Pyrex glass aquarium heater. Care was taken to rid the assay water of air bubbles due to super-saturation at the increased temperature. Immediately before filling any test jars, a sample was taken to determine the initial dissolved oxygen concentration and pH. Sometimes free carbon dioxide was determined using part of the sample taken for pH.

Each jar was filled to overflowing, a fish was inserted, and the stopper was seated firmly in place leaving no air bubbles at the top. The jar was then closed off with a screw or pinch clamp and placed in the constant temperature aquarium. The time of starting was recorded for each fish as it was placed in the jar. The fish were kept under nearly continuous observation while in the constant-temperature bath, and the time of the first complete turnover of each fish was recorded if possible. The end-point was reached when the fish was on its side on the bottom with barely perceptible gill movements.

A 130- to 135-milliliter sample bottle was immediately filled for oxygen determination by siphoning to the bottom of the oxygen bottle with a short piece of natural rubber tubing having a 3-millimeter inside diameter. The bottle was overflowed about one complete volume. The time this sample was taken was recorded as the time of death. For pH, a second bottle was filled without overflowing, and sometimes a portion of this sample was used for measuring free carbon dioxide.

Concentrations of dissolved oxygen were determined by a sulfamic acid modification of the Winkler method (Cohen and Ruchhoft, 1941, p. 622). For each sample, 100 milliliters were titrated with N/40 sodium thiosulfate using a 2-milliliter pipette graduated to hundredths, except that, when oxygen concentrations were high, a 25-milliliter burette graduated to tenths was used.

Alkalinity and free carbon dioxide were determined according to methods recommended by the American Public Health Association (1946).

Some pH determinations were made colorimetrically with a Hellige comparator, but most were made electrometrically with a Leeds and Northrup Model 7663-Al pH meter, using glass and calomel electrodes.

Table 1. Summary of Data on Lethal Oxygen Concentrations for the Northern Common Shiner

Number of fish	Temperature in degrees F.	Oxygen concentrations found lethal (p.p.m.)				Range of values for logarithmic mean	
		Minimum	Maximum	Median	Logarithmic mean	Standard deviation (p.p.m.)	Standard error (p.p.m.)
28	55 ± ½	0.38	1.40	0.52	0.54	0.412–0.714	0.515–0 571
61	65 ± ½	0.46	3.10	0.74	0.77	0.540–1.108	0.739–0.810
47	70 ± ½	0.43	4.34	0.74	0.85	0.476–1.508	0.779–0.922
39	75 ± ½	0.46	6.00	0.96	1.05	0.600–1.817	0.956–1.141
56	80 ± ½	0.56	6.20	1.04	1.23	0.687–2.195	1.136–1.327

Frequently fish were put into fresh water of the same temperature to revive. Some recovered and others did not. Total length was measured to the nearest millimeter and weights were taken to the nearest 0.05 gram. These measurements were made and recorded for nearly every fish.

DISCUSSION

The data are summarized in Table 1. The mean lethal oxygen concentration for each temperature was calculated by using the logarithm for each individual record at that temperature. The values plotted (Figure 1) are the anti-logarithms of the mean logarithms. Standard deviations were likewise computed using the logarithms. All values

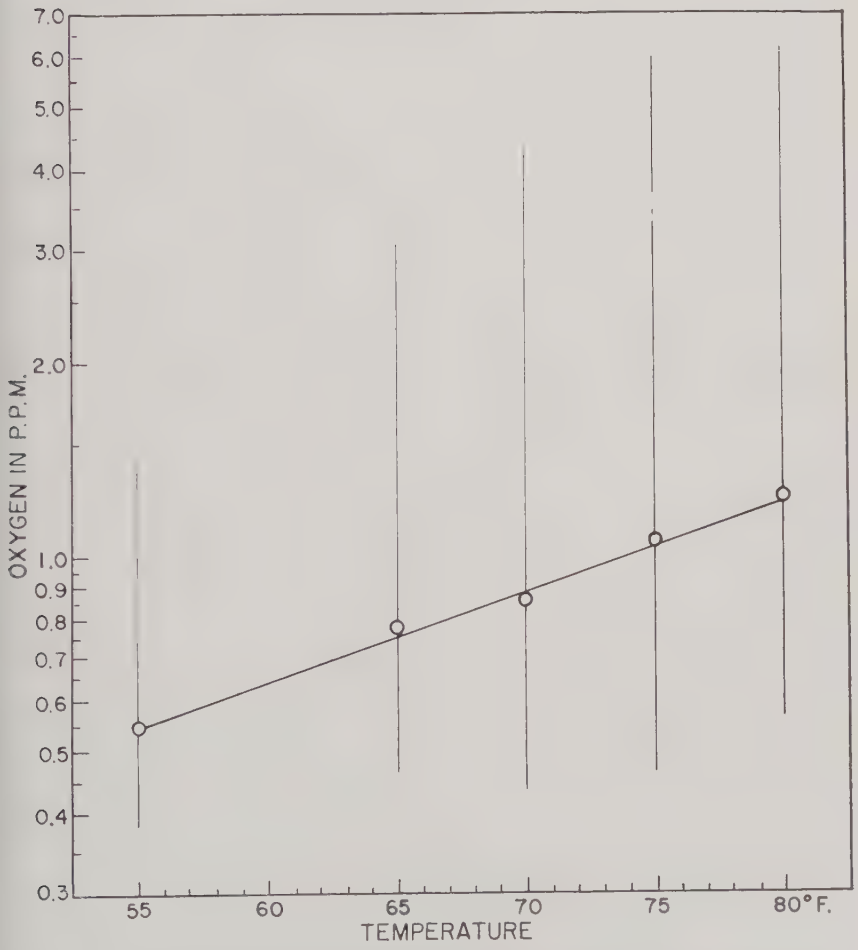

Figure 1. Mean lethal oxygen concentrations for northern common shiners; range of values for individual fish shown by vertical lines, actual means by circles.

obtained were used in computing the mean lethal oxygen concentrations unless there was some valid reason for omission such as failure to observe time of death, malfunction of temperature control during the test run, etc. Accordingly, a few high values were retained and resulted in a wide range of oxygen over which some fish could be expected to die. Field observations and stream bio-assays have been in close agreement with the mean lethal values established by these tests at several of the temperatures.

A curve for the mean lethal oxygen concentrations at the five temperatures was constructed using least squares for best fit (Figure 1). The equation for the curve is:

$$\log Y = 0.0140X - 1.0361$$

where Y = dissolved oxygen in parts per million and X = temperature in degrees Fahrenheit.

The mean lethal oxygen value at low carbon dioxide tension for northern common shiners, as given by Black *et al.* (1954) in terms of milligrams of mercury for a mean temperature of 19.1° C. (66.4° F.) has been converted to parts per million of dissolved oxygen. The computed value, 0.73 p.p.m., is only about 0.05 p.p.m. lower than that shown in the curve in Figure 1. This close agreement may only be coincidental.

Mean duration of the tests was 13 hours and 50 minutes; times ranged from a minimum of 4 hours and 27 minutes at 80° F. to a maximum of 28 hours and 52 minutes at 55° F. Mean total length of 231 fish was 62 millimeters; the range was 38 to 95 millimeters. Mean weight based on 224 fish was 1.8 grams; the range was 0.35 to 5.70 grams.

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GENERAL NOTES

SWIMMERS' ITCH IN FARM PONDS IN NEW YORK STATE[1]

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Discovery of "swimmers' itch" in a farm pond near Ithaca in Tompkins County, together with the fact that the causative organism had not been positively identified as occurring in the fresh waters of New York State, prompted the observations which are reported here. Since the organism may occur more generally in farm ponds and wildlife marshes, the finding appears to be of interest to fish and wildlife biologists.

Schistosome dermatitis, or swimmers' itch, is caused by cercariae (larval stages) of various species of trematodes, family Schistosomatidae, which penetrate shallowly into the skin of man. Their normal hosts are birds and small mammals. It has been known for many years in the Middle West where the causative agent was first determined. In Wisconsin and Michigan the incidence of swimmers' itch has been sufficiently widespread to have stimulated the organization of public control campaigns. The status of schistosome dermatitis through 1950 was reviewed by Cort (1950) whose research, with that of his students, is responsible for much of our knowledge of this disease.

In their study of the geographical distribution of swimmers' itch in the United States and Canada, Jarcho and Van Burkalow (1952) indicated two clinical cases of schistosome dermatitis for New York State. Unfortunately the sources of these records were not given. Holla and Lane (1947) reported a probable occurrence from Interlaken Lake in Westchester County. The species of snail apparently involved was *Physa heterostropha;* no specific determination was made of the cercariae observed from this snail. Orris and Combes (1953) reported a case of marine schistosome dermatitis from Cold Spring Harbor on Long Island. According to Dr. Harlan Brumsted of the Department of Conservation at Cornell University, he and several students experienced the typical swimmers' itch skin reaction during the summers of 1953 and 1954 while studying several wildlife marshes. On the basis of these fragmentary data it is impossible to evaluate the distribution and prevalence of swimmers' itch on a statewide basis.

OBSERVATIONS

The case reported here occurred in a pond adjoining the residence of the senior author. Built in 1949, and first flooded in 1950, the pond is approximately 22,000 square feet or one-half acre in size; maximum depth is approximately 8 feet. Its location makes it particularly convenient for swimming, and ever since its construction it has been used regularly for this purpose. During the summer of 1954 the children, who remained in the water a long time, occasionally complained of "bites" which subsequent experience suggests were indeed swimmers' itch symptoms. It was not until the summer of 1955, however, that the incidence was so great that the children refused to use the pond for swimming.

With no attempt at serious study, but merely to confirm the suspected occurrence of the swimmers' itch cercaria, the senior author examined some snails from the pond during the summer of 1955. A collection of several dozen were placed in glass jars in the manner routinely used for determining incidence of cercariae. A form of fork-tailed, apharyngeate cercaria, clearly a schistosome type, was very common among the several species isolated. Without attempting further identification, an experimental control procedure was planned for the pond in order to restore its usefulness as a family swimming pool.

Experimental control was carried on in August 1955 with the result that no swimmers' itch was reported in subsequent summers until 1959. As a check on the possible recurrence of swimmers' itch cercariae, sample snails were collected. In late July 1957, the authors examined approximately 30 *Lymnaea palustris*, using the

[1] The assistance of Dr. L. Penner of the University of Connecticut in verifying our determination of *Schistosomatium douthitti* is gratefully acknowledged.

crushing technique, and found fork-tailed cercariae in most of them; these were tentatively identified as *Schistosomatium douthitti*. In early September, Dr. L. Penner of the University of Connecticut examined 39 *L. palustris* from the same pond, using the isolation technique, and found fork-tailed cercariae in three of them. By experimentally infecting laboratory mice with these, he positively identified them as *S. douthitti*. In early August 1958, cercariae of this species were identified in five of 62 *L. palustris* from this pond. Although the schistosome-type cercaria was not identified in 1955, there appears little doubt that it was the same species (*S. douthitti*) identified in 1957. The life history and biology of this trematode have been thoroughly studied by Price (1931).

Cercariae of this species were found only in snails of the species *L. palustris*. Stylet and echinostome cercariae were also found in these snails, but they are not known to produce swimmers' itch. No cercariae at all were found in two other snails (*Helisoma trivolvis* and *Physa gyrina*) although only small numbers of these were examined.

CONTROL

As reported by Cort (1950), at least nine species of cercariae are known to produce swimmers' itch in North America; their intermediate hosts include snails of the genera *Lymnaea*, *Stagnicola*, *Physa*, *Gyraulus*, and *Planorbis* (*Helisoma*). The adult trematodes occur in the blood vessels of ducks, pigeons, blackbirds, canaries, and other birds; in the case of *S. douthitti*, muskrats, mice, and other small mammals serve as definitive hosts. It is, therefore, evident that control of snails is the most efficient way to eliminate the cercariae since it would be impractical to control the definitive host.

Control of swimmers' itch has been practiced routinely in Wisconsin and Michigan lakes for many years. According to the literature as summarized by Cort (1950), control efforts have usually been directed toward portions of the shoreline used as swimming beaches. Control simply involves killing all snails in the swimming area, ordinarily by using copper sulfate. The dosage recommended by the Wisconsin State Committee on Water Pollution (1946) was a combination of 2 pounds of copper sulfate plus 1 pound of copper carbonate for each 1,000 square feet of surface in hard-water lakes. In Michigan the State Stream Control Commission, through its Division of Water Itch Control, substituted lime for the copper carbonate, the lime being less expensive. Their recommendation (see Cort, 1950) was finely granulated crystalline copper sulfate plus 20 per cent of hydrated lime, by weight, mixed at the site of treatment and applied at the rate of 2 pounds of copper sulfate per 1,000 square feet of swimming area.

Because of rapid dilution of the chemical solution into the deeper waters of a lake, it is difficult to translate the above recommendations into dosages suitable for a small, contained area such as a farm pond. In the pond in question, approximately 22,000 square feet in area, a dosage of 50 pounds of copper sulfate plus 10 pounds of hydrated lime would be indicated by the Michigan recommendations. It was thought, however, that a much smaller dosage would probably suffice. Consequently, 20 pounds of copper sulfate plus 4 pounds of hydrated lime were used in August 1955. The results were so marked that even this dosage seems far too high. Not only did it kill all the snails, but it also killed a large proportion of the frogs and tadpoles in the area; there were no fish in the pond at the time. The 20 pounds of copper sulfate, equivalent to approximately 4 p.p.m. in this particular pond, would probably have killed any fish present. Trout have been known to be killed by 0.14 p.p.m. and bluegills and bass by 1 to 2 p.p.m. of copper sulfate in very soft water; 0.5 p.p.m. is usually considered safe for trout where total alkalinity is over 50 p.p.m. The total alkalinity in this pond was not taken at the time of treatment, but the mean for nine different readings taken during the preceding two years was 63 p.p.m. with a range of 35 to 90 p.p.m.

The dosage employed in the present case killed all of the filamentous algae, the *Chara*, and some of the higher plants in the pond. For several weeks after the treatment, the water was brownish and malodorous from the decomposition of organic matter. It was, of course, unattractive for swimming during this period.

REINFESTATION

By the summer of 1957 snails were again relatively abundant in the pond. As previously mentioned, some of these snails contained swimmers' itch cercariae, but the parasites were not common enough to be noticeable to swimmers. The same was true in 1958. But in June 1959 several persons using the pond were affected by swimmers' itch, and the copper sulfate-hydrated lime control was again used successfully.

In the same watershed which supplies surface water to the pond are two other

marsh-type ponds within 200 yards upstream. No effort was made to control the snail population in them. From one, overflow water runs directly into the pond under discussion, and thus could supply it with a new stock of snails. These snails might be reinfected through muskrats and other small mammals that are resident in the area and serve as reservoir hosts for the parasite.

DISCUSSION

It is possible that *S. douthitti* is widespread in New York State and that swimmers' itch will be recognized and reported more frequently in the future because of the increasing number of farm ponds and wildlife marshes that are used for swimming. Several other factors may contribute to its occurrence in the State. For example, the definitive hosts are commonly associated with farm ponds; indeed muskrats are increasing to problematic numbers in many ponds. As pointed out by Cort (1918) and corroborated by Price (1931), this parasite exhibits a low host-specificity with respect to the intermediate host. Thus, while it was found only in *Lymnaea palustris* in the present instance, it is probable that other snails are involved also. The distribution of swimmers' itch is not limited by the distribution of a single snail species. It should be noted, too, that this disease is also caused by other species of schistosome cercariae. Hence it may occur in other ecological situations and not be restricted to ponds. But, until more local data are available regarding the incidence of swimmers' itch, it is impossible to estimate accurately the extent of its distribution in New York State.

If a pond used for swimming becomes heavily infested with swimmers' itch cercariae, the only practical course is to control the snails. This is ordinarily done with a molluscicide such as a mixture of copper sulfate and lime. Collection of the snails is usually ineffective, because it is virtually impossible to reduce the population drastically in this manner. If, however, a pond is lightly infested and chemical control does not seem warranted, a swimmer may use prophylactic measures to eliminate much of the hazard of contracting swimmers' itch. For example, swimming only in deep water greatly reduces contact with the cercariae since they are found primarily in shallow water. Furthermore, the cercariae tend to remain attached to the skin for some time before penetrating, and, because evaporation of water from the skin appears to stimulate penetration, wiping oneself thoroughly upon emerging from the water also eliminates much of the hazard.

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PERSISTENCE OF WINTER DEER-PELLET GROUPS IN ADIRONDACK FORESTS

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Bennett *et al.* (1940) first described a pellet-counting procedure as a means of estimating white-tailed deer populations. This procedure has since become a widely accepted research and management tool.

Deer population estimates are possible because pellet deposition is approximately proportional to the amount of deer use. There are several sources of error which make this relationship only approximate, as discussed by Dice (1941), Steinhoff (1947), and McCain (1948). One of these is the likelihood that deer pellets possess varied life expectancies. For example, some feel that insects, mollusks, or fungi may destroy the identity of pellet groups in a matter of weeks, while others suspect that such groups may last for many months. Thus, deer-pellet groups counted on a plot may represent accumulations of from only a few weeks to many months.

A study was undertaken on the Archer and Anna Huntington Wildlife Forest Station[1] to obtain data on the life of deer-pellet groups. It was anticipated that group

Table 1. Number of Deer-pellet Groups Marked in Three Forest Types in the Adirondack Region and Subsequently Recorded* After Various Intervals

Item	Forest type: Sugar maple-beech-yellow birch	Red spruce-yellow birch	Red spruce-balsam fir	Total
1956				
Number marked	20	20	20	60
Number recorded				
September 1956	19	20	19	58
November 1956	1	12	7	20
June 1957	6	15	10	31
June 1958	1	8	3	12
1957				
Number marked	20	20	20	60
Number recorded in June 1958	3	14	11	28

* Figures represent those groups that would have been tallied by a field crew making a routine check.

[1] A property of the State University College of Forestry at Syracuse University, located in the central Adirondack region, near Newcomb, and operated for the conduct of wildlife research.

longevity might vary with different vegetative types, so observations were made in unlogged tracts of each of three forest cover types[2], namely, sugar maple-beech-yellow birch, red spruce-yellow birch, and red spruce-balsam fir. In June 1956, 20 pellet groups believed to have been deposited the previous winter were randomly selected and permanently marked in each of the three types. This procedure was repeated in June 1957.

The pellet groups marked in 1956 were checked in September 1956, November 1956, June 1957, and June 1958. The groups marked in June 1957 were checked in June 1958. In checking the marked groups, the observer simply recorded whether or not a group might have been counted if he were engaged in a deer-pellet count. The records are summarized in Table 1.

The results indicated that pellets persisted for long periods in Adirondack forests. For all forest types, pellet groups deposited in the winter of 1955–56 and marked the following June were very evident in mid-September of the same year. Many of these groups were sufficiently covered by the October leaf fall that they were not easily visible in November. However, concealment by the leaf fall was only temporary,

TABLE 2. ANALYSIS OF VARIANCE OF LONGEVITY OF MARKED DEER-PELLET GROUPS IN THREE FOREST TYPES IN THE ADIRONDACK REGION §

Data (number of groups evident 1½ years after deposition)

Replication †	Forest type		
	Sugar maple-beech-yellow birch	Red spruce-yellow birch	Red spruce-balsam fir
1	2	5	4
2	4	7	3
3	3	4	5
4	0	5	5
5	0	8	4
Total	9	29	21

Analysis of variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Value of *F*
Between types	2	40.6	20.3	9.2**
Within types	12	26.4	2.2	....
Total	14	67.0	....	....

** Significant at the 1 per cent level of probability.
§ In each type, 40 groups were marked.
† In each type, each replication represents eight randomly selected groups.

because in June 1957 it was estimated that 31 of the 60 groups would have been tallied in a deer-pellet count. Similar results were obtained for the groups deposited during the winter of 1956–57 when 28 of the 60 samples marked in June would have been tallied in a count a year later. When the pellet groups marked in June 1956 were

[2] These are types 25, 30, and 33, respectively, as described by the Society of American Foresters (1954).

checked in June 1958, 2½ years after deposition, 12 were still visible and would have been tallied in a deer-pellet count.

Data were obtained which suggested differential deer-pellet longevity in the various forest types. Combining the two sets of records, observations of 40 groups in each type were available. These were divided, by random selection, into five replications of eight groups each. The data are presented in Table 2 together with an analysis of variance.

The individual entries in this table represent the number of marked groups that would have been tallied on a count conducted 1½ years after the pellets were deposited. Only nine of the 40 groups in the sugar maple-beech-yellow birch type persisted for this period. However, 29 in the red spruce-yellow birch type and 21 in the red spruce-balsam fir type were still in evidence. The *F* value of 9.2 is significant at the 1 per cent level of probability. Clearly, decomposition and/or concealment was more rapid in the sugar maple-beech-yellow birch forest type than in the types containing coniferous trees.

In the central Adirondack region the growing season is short and the summers are cool. The soils are almost entirely of the mor type. In comparison with other regions there may be relatively few biological agents to reduce deer-pellet groups to indistinguishable material. Of course, the groups 2½ years old showed indications of breakdown, but the rate of pellet destruction was slow, and in many cases pellet groups 1½ years old looked very similar to groups only 6 months old. It seems most unlikely that the age of pellet groups could be reliably judged on the basis of the condition of the individual pellets.

Since it is generally necessary to conduct extensive pellet counts with relatively inexperienced field crews, the aging of pellets certainly could not be relied upon to separate groups on the basis of the year in which they were deposited. Therefore, in order to assure accuracy in interpreting pellet counts, it would be necessary to establish permanent plots and to clear the plots of all deer pellets as they were counted. In subsequent counts, the observed pellets would then be known to have accumulated since the plots were cleared.

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EFFECT OF FYKE-NET POSITION ON FISH CATCH

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The fyke net is an efficient trapping device which can be used to obtain samples of fish populations which frequent the shallower areas of lakes and ponds. In using these nets there is some question as to whether or not the position of the net will have an effect upon the fish catch, i.e., will a net set parallel to the bottom contours catch as many fish as a net set perpendicular to them.

To determine the effect of net position, fyke nets were set both parallel and perpendicular to the lake-bottom contours in each of the three major lakes at the Archer and Anna Huntington Wildlife Forest Station[1]. The work was done during the period from the last week of June to the first week of September. The fyke nets used

TABLE 1. NUMBERS OF FISH CAUGHT IN FYKE NETS SET PARALLEL OR PERPENDICULAR TO LAKE BOTTOM CONTOURS, AND VALUES OF CHI-SQUARE

Lake and type of set	Red-bellied sunfish	Common bullhead	Common sucker	Yellow perch	Common sunfish	Total
			Numbers caught			
Wolf Lake						
Parallel.....	203	14	252	...	...	469
Perpendicular...	223	9	71	...	...	303
Catlin Lake						
Parallel.....	198	238	94	60	368	958
Perpendicular...	237	108	109	47	275	776
Rich Lake						
Parallel.....	175	706	29	70	300	1,280
Perpendicular...	111	512	7	34	291	955
Total						
Parallel.....	576	958	375	130	668	2,707
Perpendicular...	571	629	187	81	566	2,034
			Values of chi-square			
Sum chi-square....	18.76*	88.80*	115.96*	14.04*	13.58*	102.06*
Pooled chi-square..	2.18	68.20*	62.88*	11.38*	8.44*	95.54*
Heterogeneity chi-square.....	16.58*	20.60*	53.08*	2.66	6.14*	6.52*

* Significant at the 5 per cent level.

were constructed from 1-inch-square-mesh netting and had a 3-foot entrance hoop to the trap cone as well as two 15-foot wing nets (additional leader nets were not used). They were set in groups of two, in water 5 to 10 feet deep, within 100 feet of each other.

In each group, the net set perpendicular to the bottom contours was placed so that the entrance faced toward deeper water. The one set parallel to the bottom

[1] A property of the State University College of Forestry at Syracuse University, located in the Adirondack region, near Newcomb, and operated for the conduct of wildlife research.

contours was placed so that the entrance faced away from the other net. In this way competition for fish between nets was held to a minimum, yet the arrangement allowed the nets to sample the same general area.

The combined catch from seven years of sampling in the three lakes is given in Table 1. Catch figures are given for the red-bellied sunfish (*Lepomis auritus*), common bullhead (*Ameiurus nebulosus*), common sucker (*Catostomus commersonnii*), yellow perch (*Perca flavescens*), and common sunfish (*Lepomis gibbosus*). The totals indicate that the parallel nets caught more fish than the perpendicular nets. To evaluate this apparent difference, chi-square tests were applied to the data.

The hypothesis tested was that the parallel and perpendicular net catches were in the ratio of 1:1, or in other words they were equal. Three chi-square values were calculated for each set of data (Table 1), i.e., sum chi-square, pooled chi-square, and heterogeneity chi-square (Snedecor, 1956, p. 214). The sum chi-square values show that for all species the parallel and perpendicular net catches deviated significantly from the 1:1 ratio at the 95 per cent level of probability. The pooled chi-square values, except that for the red-bellied sunfish, are all significant indicating that this deviation consistently tended to favor the parallel net set. In the case of the red-bellied sunfish, however, the perpendicular sets caught more fish in two of the three lakes. Inasmuch as four of the five heterogeneity chi-square values are significant, the ratio of the parallel net catch to the perpendicular net catch was variable rather than constant.

It may be concluded that a fyke net, set parallel to the bottom contours in these lakes, will on the average catch more fish than one set perpendicular. The percentage increase in catch of the parallel set, however, will not be constant from one fishing period to the next.

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